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COUNTRY ROADS.*

A hand book of rules and reasons; showing why the country roads should be made better and how to make them so.

By ISAAC B. POTTER.

I.

ROAD PHILOSOPHY.

HIGHWAYS are what we make them. In this country they are a creation of the disreputable trinity of bungle, blunder and botch, and like the common roads of other nations they bear the imprint of their makers' skill. A country road, like every other piece of human work, is bad, or tolerable, or fair, or good, or excellent, or splendid, just in proportion to the amount of sense and ingenuity that has been put into its construction. Every well done job is a testimonial of its maker's intellect; every good law is a monument to the intelligence of a nation.

In my judgment the reason why our country roads are bad is because they haven't had a sufficient place in the public mind. They are slovenly imitations of a bad model; chums to custom and strangers to sense. They have cost us thousands of millions of dollars, but not an hour of thought; and while our brains have been gathering wool in distant pastures our money has turned into mud. And I believe that every citizen of this country who owns a wagon should paint in conspicuous letters, on each end of it, these words: "He that hath brains to think, let him think." And then, if he is brave enough to tackle a single full-grown thought on the subject of country roads, and brainy enough to entertain it for sixty mortal minutes, he will perhaps know what his horse knew years ago. He will know that the country road is an expensive, inferior and sometimes useless and cruel affair; expensive to the farmer and cruel to every beast he employs. And let me say that I have never had the heart to blame a kicking horse. It is the only way he has of stating his opinion—his one solitary method

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of filing an objection. When he kicks too much I always think of the other horses that don't kick enough; and I have seen it done under perfectly justifiable conditions—under circumstances of cruel provocation that would excuse manslaughter and justify an earthquake; and though the air was filled with splinters and profanity, I have had the happy satisfaction of seeing a dumb and patient brute deliver an eloquent and emphatic argument in behalf of down-trodden labor. The only beast that was ever known to talk is said to have called Mr. Balaam's attention to the bad going.

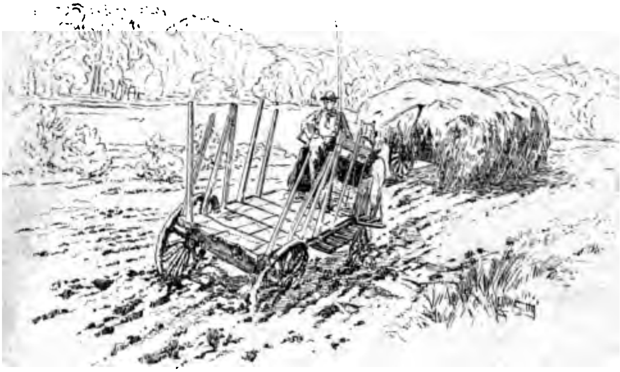
"He That Hath Brains to Think, Let Him Think."
Actual scene in an American country town in the Spring of 1892. Drawn from a photograph in possession of the author.

If all the sixteen millions of farm horses in this country—all the faithful beasts that have become galled and jaundiced and wind-broken and spavined and foundered and mangy in our service—should make up their minds to balk and shy at every mud hole, and, for every blow, to stand in their tracks and kick holes in the firmament, the question of better roads would be forever settled. "People are sooner reclaimed by the side-wind of a surprise than by downright admonition."

And so I say to every roadmaker, "He that hath brains to think, let him think." It is good for him—as good for himself as for the road;—good, healthful, creditable and profitable exercise. When a man begins to run short of ideas, the brain is the magician that fills the storehouse of his reason and lights his lamp of knowledge, and when his brain fails, the light of his manhood goes *out and he* becomes the companion of the insane—entombed with *the animate* dead. It pays to think. There's money in it.

Thought is the sire of all success and the more a man thinks the more of a man he is. Men rarely get rich and never great by accident.

And I also believe that no self-governed people can have a truly successful government by accident or chance; that no nation can reach its best development without doing even justice to every citizen; without dealing public favors to the merchant and to the farmer in the same measure. Thousands of millions of public money have been spent to build bridges and dredge channels and open harbors and erect wharves, to subsidize shipbuilders and to boost the building of railroads, and all these have enriched the merchant and the manufacturer, and the railroad proprietor, and have made town and city life comfortable and convenient. Most of this money has been spent in a sensible way. It has paid for systematic, well-done, permanent work; work planned in the brain, wrought by skill and finished by rule and reason, and it has paid cost and profit to its makers, over and over again.



WHISTLING JIGS TO THE MILESTONES.

"With a hundred years of experience we are paralyzed by the presence of a simple mixture of dirt and water."

View showing wagons stuck in the mud at the outskirts of Des Moines, Iowa; drawn from photograph in possession of the publisher.

At the border line of every city and every town these improvements have stopped. The boundary of every farm has been a forbidden threshold. We have known little and thought less about the making of our wagon roads and our chain of public improvements is one link short. The millions that we spend each year for the improvement of the country roads is not used to advantage. It is spent by a system that squanders labor, wastes money and brings no per [illegible] s. Traffic between farm and market is costly and [illegible] ith scant loads our farmers struggle through miles [illegible] for weeks at a time every mud hole is an impassable [illegible] pond. The panting horses stand for hours in bonda [illegible] elpless farmer can only whistle jigs to the milestone [illegible] e wheels of industry in town and city go smoothly o [illegible] d success. With a hundred years of experience we [illegible] by the presence of a simple mixture of dirt and wat [illegible] ot a nation of road makers: we have not thought.

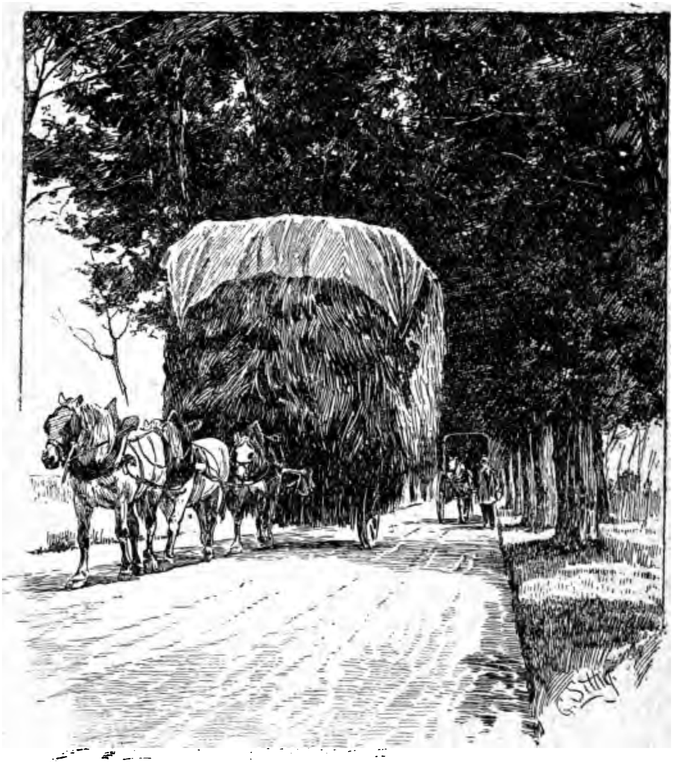
A Country Road After a Heavy Shower.

"Let us admit that a general downpour for three or four days before election will rob 100,000 intelligent farmers of their votes; * * that many a state government has been changed by a change in the weather, and that many a public officer whom the people did not want has been lifted into place by a lingering equinox." Picture drawn from a photograph in possession of the publisher.

And now in the matter of making and mending these country roads, perhaps there's a thing or two that we have been doing the wrong way. And if that is so, let us be honest about it; let us be manly enough to admit it. A mistake is nothing to be ashamed of. The world is full of errors and blunders; they are fashionable; and a man who is broad enough and honest enough to admit that he has made a mistake will feel himself grow and swell in brain and body when he makes the confession. He will know that he has pushed a little of the fog out of his intellect and cleared the horizon of his knowledge, and on the bright page of his conscience [illegible] will give himself credit for being a wiser, manlier man to-day [illegible]an *he was yesterday.*

It has been tried now and then by some heroic soul in every class of society, except office holders and political bosses, and every experiment has proved the rule. The world will always forgive the man who makes an honest mistake and will do homage to the brave fellow who admits it.

And let us admit, in the first place, that we have never had real good going. Let us admit that these country roads are about as



"A GOOD ROAD IS A SPLENDID INVESTMENT."

Hauling hay to market on a Normandy road. These loads weigh four tons and upwards. The road is always keep smooth and dry by intelligent care and the market is always accessible. Drawn from a photograph in possession of the publisher.

bad as roads can possibly be; that they are frost laden and wet and soft and soggy in Spring and Fall, dry and dusty in Summer, and rough the year round. These roads are all out doors, all in plain sight; everybody knows they are bad; let us be honest and confess the fact.

Let us admit that these bad roads keep us away from town and from each other; that we can't get to market when prices are good; that we are hauling scant loads, racking our wagons, killing our horses and rasping our tempers; that they keep our wives shut up like cattle in a pen; that they increase our solitude, keep our children from school and send our young men to the cities with a solemn oath upon their lips that they will never till the soil. And let us admit that these miserable streaks of rooted soil interfere with our liberties—with our citizenship; that a general downpour for three or four days before election will make a mud blockade all over this great country and rob a hundred thousand intelligent farmers of their votes; that many a state government has been changed by a change in the weather, and that many a public officer whom the people did not want has been lifted into place by a lingering equinox. All this we know; let us admit it.

The homes of our farmers are too far apart. They have lonely habitations and lonesome families. Something is wrong. They lack the means of being sociable; libraries, companionship, chances for improvement, opportunities to travel, to swap ideas, to do business and to increase it.

Everybody except the farmer measures distance by time and cost. The man who lives in the city rides ten miles from home to business in thirty minutes, at the cost of half a dime. A hundred years have changed that city from a howling wilderness to a howling metropolis. It began with a one-story house and a by-path. Then there was a two-story house and a dirt road; then brick houses and sidewalks, and then more people and more houses. The dirt road gave way to the cobblestone pavement, and the cobblestones to granite blocks, and in many cases the blocks to asphalt. The people traveled at first on foot, then in stages and omnibuses, then in horse cars and now in electric, cable and elevated railroads. Their heads and hands have worked together. They have thought. From year to year the cities have demanded swifter means of travel and transportation, better and quicker and surer methods of doing business. It is all a matter of speed, convenience, facility; all these mean the same thing—economy.

Just across the street there is a new building about to be put up. The fifty-foot lot has just been bought from the trustees of a dead man's estate at $4,000 a front foot. The location is good, easily reached, surrounded by improvements, enriched by the products of thoughtful labor, a splendid place to do business. Tear up the pavements on that street and that lot would be worth [illegible]0,000 less; take away the surface cars and elevated roads and off goes $20,000; remove the telegraph and telephone connections and the price goes down $20,000 more; and now if we wipe out the rest of the town and leave that new building standing alone by itself, connected with a distant town by a mud road, we couldn't rent it at $100 a year as a storage house for soap fat. That lot is stony and barren, without fertility and without natural value. A thousand acres of such soil would not sustain a colony of fleas. Its splendid value is purely the creation of brainwork and handiwork; entirely the result of human improvement; largely the result of quick means of communication—of good going. Neglect is a great destroyer. Corner lots in ancient Babylon can be had for a song.

Of course, everybody will not understand this. "There are some men," says Burke, "formed with feelings so blunt that they can hardly be said to be awake during the whole course of their lives." But if the reader that has brains to think, will think, he will see that there is some philosophy in the argument for better roads, just as there is good sense in urging every improvement that brings closer together every two men who have business with each other.

Every thought begins with a fact. There must be something to think about. There are things to think about—facts to consider—in the road question. How do these facts affect the public?—the public business?—the prosperity of the nation?

Last year our railroads carried a thousand million tons of freight.* Every year the amount increases. Every pound of this freight is carted and carried over our roads and streets before it gets to the railroad. Millions of tons more are hauled in wagons and sold in the country towns and consumed by the local buyer. Here is the farmer's end of it: Hay, fifty-four million tons. Think of it! Look at the picture on page 3, and think of hauling fifty-four million loads of hay to market on roads like that. Ninety million tons of cereals; six million tons of potatoes; two million tons of cotton; total, one

A Load of Hay in Germany.

This load weighs four and a half tons and was hauled twenty-two miles over country roads. For shorter distances a single horse is used to haul loads of immense size. Drawn from photograph.

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* The statements of quantities and values made in this book are taken from the last official bulletin of the United States Census Office at Washington, and from the latest "statistical abstracts," prepared under direction of the Secretary of the Treasury. The author states the quantities and values in round numbers for the convenience of the reader. The exact official figures are somewhat in excess of the amounts here given.

hundred and fifty-two million tons, not counting the mud on the wagon wheels. The road and the wagon are the twin handmaidens of agriculture that attend the farmer on every journey to market, and they are forever at odds with each other. If the man who sold the farmer that wagon had tried to sell him that road, homicide would have become a virtue.

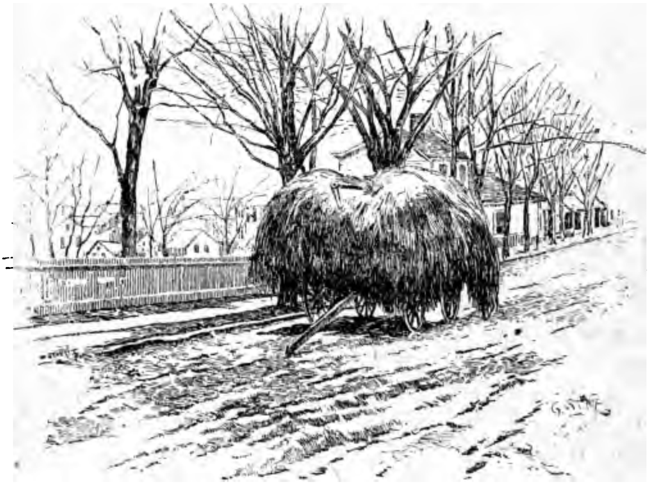
One hundred and fifty-two million tons of produce. Five hundred million dollars paid for farm implements and machinery to harvest it. Twelve hundred millions invested in farm horses and mules to drag it to market. Think of it! Think of being director in a corporation with that amount of business on hand, with countless millions of paid-up capital invested, and think of doing business in a mortar bed.

Think of waiting for the mud to "dry up." Sixteen million horses and mules idle in the stable. Four million dollars a day for horse feed; twenty-eight millions a week. Think of the loss of time and labor; the dwarfed and shrunken values of our farms; of the slack supply and good prices when the roads are impassable; think of the procession of farmers that rush to town and glut the market in the first days of dry weather, and think of the paltry prices they get when everybody is trying to sell to an overstocked merchant. From the standpoint of profit, in dry weather and wet, the badly kept dirt road is much the same. There is little difference between selling a full load at half price and half a load at full price.

Another thing—every improvement is a herald of prosperity; every good country road increases the value of every farm that fronts it. Raise the value of real estate on American farms five per cent. and you add six hundred and fifty millions to our rural wealth. Put a like increase on the value of farm products, live stock and farm machinery and you gain three hundred and fifty millions more. Decrease the cost of hauling one year's crop of hay, cereals, potatoes, tobacco and cotton, by only ten cents per ton, and you save fifteen million of dollars. These are not all the items. They will suffice.

Many of us do not know that bad roads are responsible for so many of our woes, because we have not thought. Some of our farmers are patient and many of them are contented with these roads because they do not know the value of a good one. A good road is a splendid investment. There never was a good road made in any civilized country on earth that didn't pay a hundred per cent. a year on its cost. It raises the value of every acre; invites us to market when prices are good and takes us out of the clutches of the commission pirates who sell our goods behind our backs at their own figures, keep their own accounts and pay us a pittance for our toil and trouble. A good road shortens distance, saves time, wagons, horse flesh, harnesses, increases the load and lessens the burden and makes it possible to haul two tons to market with the same power that now leaves one ton stuck in the mire. It brings us closer together, drives out gloom, makes neighbors of hermits, discounts every farm mortgage and brings joy and contentment to every community. Imagine a man, knee deep in the mud, trying to look cheerful!

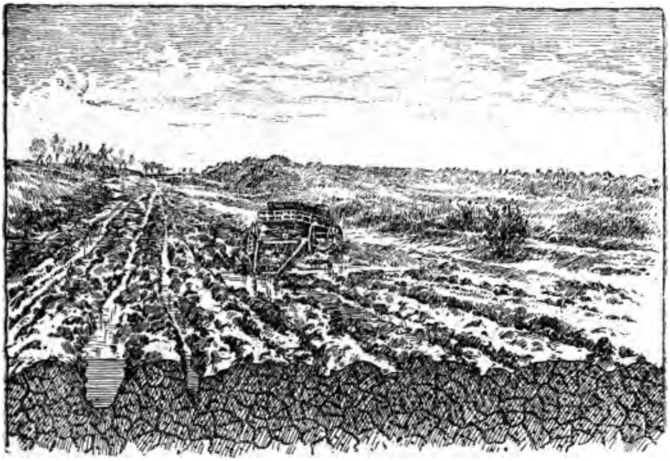
Every one of us ought to be glad to know these things and proud of the privilege we have to right every wrong that confronts us. I am in favor of free government because it puts a premium on thought; because it invites all the people to have ideas; because it summons its best men to its councils; because it pays tribute to philosophy and rewards invention; because it has substituted intellectual for physical power; because it has made it popular for people to have big heads and small feet. Nowadays, when a man runs for office, his party prints ten thousand portraits of its candidate, just to show the people what a bright and brainy fellow he seems to be. Fancy a candidate for congress being advertised by a lithograph of his legs and boots!



THE AVERAGE AMERICAN LOAD OF HAY.

Load of 1,700 pounds in the village street at Fishkill, N. Y. One of the whiffletrees was broken in hauling the load over the rutty surface, and the driver left the load standing here while he went to a village shop for repairs. From photograph in possession of the publisher.

Every citizen ought to contribute his mite of sense to the management of the public roads. It is the most important public question that can claim his attention. The tariff puzzle is a joke to it. And I will tell you why he should think of it. Every man who lives in a free republic, every man whose rights are fortified by the ballot and whose country has made a compact for his eternal protection; every man whose home is guarded by the strong arm of his neighbor, has a double reason to think—a two-fold chance to add to the splendor of his manhood and to the progress of his state. He owes something to his country as well as to his family, and if he is a good father and a kind husband there is abundant reason why he should rear a family of patriots and why he should try to make his country the best and grandest in the world. When he has thought out and wrought out the best way of doing a thing, when he has been diligent and successful in his business, he can afford to contribute a little of his skill and knowledge to the guidance of public affairs. Thinking always for ourselves is stingy, miserly business. To every one of us has been given the double power of sovereign and subject and with it a double responsibility that, like a two-edged sword, cuts both ways. The business of a republic is the business of every citizen. We cannot afford to starve the watch dog that keeps the thief and



IMPORTANT COUNTRY ROAD, NEAR ALBANY, N. Y.

The road surface shown in this picture is drawn from a photograph. The section of road shown in the foreground is drawn to show the condition of a saturated earth roadway; the small channels and interstices between the particles of earth being filled with water which cannot run off till drainage is provided for.

the tyrant from our threshold, and every man ought to give his best thought to the government that insures him the right to think and to forever speak his thoughts. And we cannot afford to whisper a syllable of disrespect against the humblest borough in the land until we have tried our level best to make it truly respectable.

For thousands of years the journey of progress was slow and sad. Some people wonder that mankind is not more thoughtful. To me it is almost a marvel that men think at all. They haven't been long in the business. They haven't had a respectable chance. For centuries thought was chained in the dungeon of the brain. Ignorance was a despot before whom all the world was hushed in fear. The fangs of force were held above every honest heart, and every ambition was clutched and strangled at its birth. Reason was in exile. The moral, civil and religious codes were one—made and mapped in bigotry and laid in the lap of every infant; a heritage of hide-bound superstitions and absurdities. Most of the arguing was done by thumb-screws and firebrands, and all the thinking was done at headquarters.

"LET US ADMIT IT."

All public improvements were made by order of a king or a priest or a conquering general. And I want to be perfectly fair. I want to admit that some of these improvements were very good; some of them were superb. When one of these gentlemen found himself in the midst of an idle spell he sometimes began the creditable task of improving his kingdom. It kept the people busy, stopped the breeding of mischief and cured calamity. That the improvement was needed was a fact which the poor subject had neither the intelligence to foresee nor the right to decide. There was no congress to consider, no legislature to determine, no committees to confer, no particular form to follow. The king had no one to convince but himself; it was his divine right to have what he wished at other people's expense.

And so, between raiding their neighbors and raw-levying at home, these aristocratic swashbucklers sometimes built splendid castles and stately cathedrals and roads that gladdened all the land; roads over which their armies marched dry shod for hun dreds of miles; magnificent roads that made neighbors of all the people, and that stand to-day as mute monuments of barbaric sense. And even the people who claimed no earthly right to know anything, knew that the world had become better and brighter; they knew that these lords of misrule had wandered into the path of progress; and all the horses and all the mules knew it.

By and by the people were allowed to think,—just a little, and occasionally to mention it. The rulers found it good policy to approve what they could no longer prevent—and so they commended the habit of thinking—just a little. And from thinking and talking about it people began to improve. They began to grow and to expand and to learn from one another—and about some things they changed their minds. They questioned the divine right of kings and pruned the royal prerogatives. They discovered that all new born babes were pretty much alike and that all the mortal dead were dust; they found that every man had seven holes in his head and that all these were made to use; they coined a new word and put it in the mouth of progress and called it "Liberty," and one day a few brave and splendid men met together and subscribed their names to the solemn declaration that all men are created equal. They tried the experiment of self-government. All this was wrought in the brain. Like every other improvement, it was the child of thought. He that hath brains to think, let him think.

I am in favor of working out the problems of human happiness and prosperity just as we have solved the question of human right. We are the sole proprietors of our own country and of ourselves, and this republic can be no better than we make it. The most powerful and most expensive form of tyranny is the tyranny of custom. "Men do more things from custom than from reason." If we are taxing ourselves and dwarfing our growth by a senseless custom, let us be rid of it. Let us remember that all riches come from the ground; that the food we eat and the clothes we wear are the products of the soil; that agriculture is the great source of wealth; and that no nation ever became great whose farmers were not great. And, remembering these things, let us, as sensible, thoughtful men and women, direct our energies to the work of bringing the city and the country a little closer together; to the revising of these bad laws that were copied a hundred years ago from the moth-eaten and now discarded statutes of the old world. Let us hear no more of the decline of agriculture;* let us do justice to all men and to all classes, and let it never be said that that man was an American farmer who left, as his last will, a sealed document containing the impressive words: "I owe much; I have nothing; I give the rest to the poor."

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* In 1891, Gov. Campbell of Ohio, in a public address at Marysville, declared that the farms of that state had decreased in market value by at least $220,000,000 in the last ten years, although the official census reported an increase in total wealth of the state during the same period, of $243.000,000. This would seem to show a gain in town and city values of $463,000,000, as against the large falling off in farm values just noted. In the ten years ending in 1890, there was a decrease in population in 30 agricultural counties in Illinois, 28 in Ohio, 25 in Indiana, 27 in Iowa, 21 in New York, and in a similar way Michigan, Wisconsin, Minnesota, Missouri and other states show a decline in rural population in the same decade.

Of the two and one-quarter millions of population in the State of Massachusetts about 1,600,000 are included within 47 cities and towns, each having a population of 8,000 and upward. The population of these cities and towns has increased by 403,000, or about 35 per cent. in the last ten years, while the increase for the entire state was only about 25½ per cent., an aggregate which is shown by the official reports to have been almost wholly sustained by the increase noted in the several cities and villages of the state, as against a marked decline in many agricultural towns.

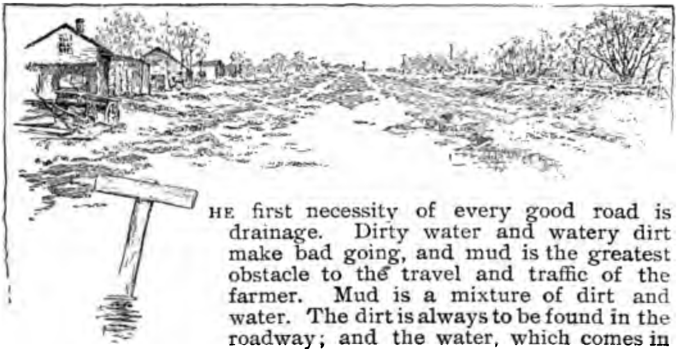
Leaving out the populous cities and towns and referring only to the purely agricultural districts, there will be found in Massachusetts only 149 townships which show an increase of population within the last decade as against 156 townships in which the official count has determined an actual falling off. To show that these conditions are not, however, peculiar to Massachusetts alone, an official census bulletin recently issued by the General Government gives place to this statement:

"In the North Atlantic division 51.58 per cent. or more than one-half the entire population is contained in cities of 8,000 or more inhabitants. During the past ten years the city element in this division has increased 43.53 per cent., while the total population has increased but 19.95 per cent. This relative increase is well distributed among the several states of this division, with the single exception of Vermont, whose city element has increased but little. In Maine, Vermont, Massachusetts and New York the numerical increase in the city element is greater than the increase of the total population, so that in these states the rural population has actually diminished in number."

II.

ROAD DRAINAGE.

WHY DRAINAGE IS IMPORTANT—NO WELL DRAINED ROAD CAN BE LONG MUDDY—AMOUNT OF RAINFALL—SIDE DITCHES; HOW TO MAKE THEM; THE DITCH GAUGE; HOW TO MAKE AND USE IT—LOCATION OF SIDE DITCHES—UNDER DRAINS—LEVELING—STONE DRAINS AND TILE DRAINS; SELECTING TILE; SIZES TO BE USED; LAYING TILE; TOOLS AND MATERIALS; TABLES OF SIZE, COST AND CAPACITY.



THE first necessity of every good road is drainage. Dirty water and watery dirt make bad going, and mud is the greatest obstacle to the travel and traffic of the farmer. Mud is a mixture of dirt and water. The dirt is always to be found in the roadway; and the water, which comes in rain and snow and frost, softens it; horses and wagons and narrow wheel tires knead it and mix it, and it soon gets into so bad a condition that a fairly loaded wagon cannot be hauled through it. We cannot prevent the coming of this water, and it only remains for us to get rid of it, which can be speedily done if we go about it in the right way. Very few people know how great an amount of water falls upon a country road, and it may surprise some of us to be told that on each mile of an ordinary country highway within the United States (three rods wide), there falls each year an average of twenty-seven thousand tons of water. Water is a heavy, limpid fluid, hard to confine and easy to let loose. It is always seeking for a chance to run down hill; always trying to find its lowest level. In the ordinary country dirt road the water seems to stick and stay as if there was no other place for it; and this is only because we have never given it a fair opportunity to run out of the dirt and find its level in other places. We cannot make a hard road out of soft mud, and no amount of labor and machinery will make a good dirt road that will *stay good* unless some plan is adopted to get rid of the surplus water. To state it briefly, every country road should have side ditches—one on each side of the roadway, wherever possible.

Side Ditches.—Side ditches are necessary because the thousands of tons of water which fall upon every mile of country road each year in the form of rain or snow should be carried away to some neighboring creek or other water channel as fast as the rain falls and the snow melts, so as to prevent its forming deep mud and destroying the surface of the road. When the ground is frozen and a heavy rain or sudden thaw occurs, the side ditch is the only means of getting rid of the surplus water, for, no matter how sandy or porous the soil may be, when filled with frost it is practically water tight, and the water which falls or forms on the surface, must either remain there or be carried away by surface ditches at the sides of the road.

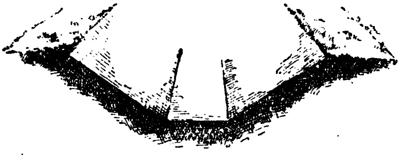


FIGURE 1.

Showing proper form of ditch to be dug along the side of the country road. The sides are broad and flaring and have slopes of "1½ to 1;" that is, the slope extends outward a horizontal distance of 1½ feet for each one foot of vertical rise.

A side ditch should have a gradually falling and even grade at the bottom, and broad, flaring sides. Look at Fig. 1. It shows you the form which a side ditch should have. Its banks will not cave in. It can be easily cleared of snow, weeds and rubbish; the water will run into it easily from each side and it is not dangerous to wagons and foot travelers. It is, therefore, a much better ditch than the one shown in Fig. 2, which represents the kind of ditch very often dug along the country roadside.

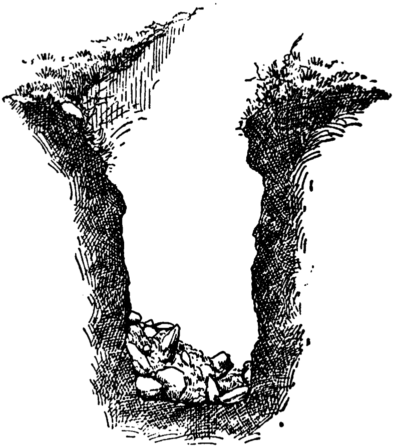


FIGURE 2.

Showing form of side ditch frequently seen along country roads. The sides of the ditch are too steep and quickly "cave in" at sides and edges, thus obstructing the flow of water at the bottom. This form of ditch is also dangerous to travelers.

The Ditch Gauge.—To *make the* ditch shown in

Fig. 1, and to make it with even, flaring sides, so as to produce a workmanlike job, we had better use a rough gauge like that shown in Fig. 3.

This gauge is made to fit the proper cross section of a good surface ditch, and by "fitting" it in the ditch as we go along, the shape of the ditch will be kept uniform and correct. The gauge can be made of any convenient strips of wood and the dimensions are described in the text below the figure.

Location of Side Ditches.—If possible the side ditch should be about three feet from the edge of the traveled roadway, and there should generally be a side ditch on each side. If the traveled roadway is fourteen feet wide, there will then be twenty feet of clear space between the ditches; if the traveled roadway is sixteen feet wide, there will be twenty-two feet of clear space. Now and then we shall find a place where the roadway is too narrow for these figures, and in such cases we may have to get along with a single ditch and a narrow roadway. The best rule is the rule of common sense.

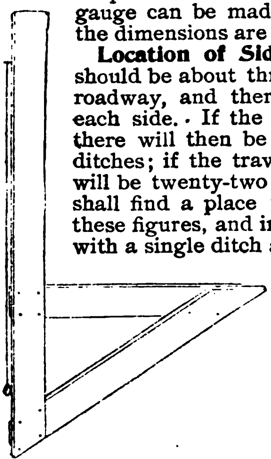


FIGURE 3.
Showing "ditch gauge" to be used in making proper slope at sides of ditch. The gauge is made of light strips of wood, about three inches wide and one inch thick. The upright strip is four feet long. The horizontal strip is eighteen inches long from the left side of the upright piece (as you face the figure) to the point of gauge at the extreme right, and the top of the horizontal strip is one foot above the bottom point of the gauge.

Sometimes side ditches are entirely omitted and the shallow gutters at the sides of the wagonway are depended upon to carry off the surface water. This form of construction is shown in Fig. 5. These gutters sometimes serve a good purpose, especially when made in regular shape and with good grade (as can be done with a good road machine), but they are likely to be clogged and destroyed by passing wagons, and for this reason alone it is better to make one or more separate side ditches when possible. When the highway space is too narrow to admit of the use of a side ditch, and in fact, in all cases, it is important to keep the angle ditches at the edge of the roadway clean and smooth by cutting out the angle and smoothing the surface; using a road machine and roller if these can be had. The work of a road machine in cleaning out an angle ditch is shown in Fig. 6. On this point more will be said in the next chapter.

Common side ditches catch surface water and surface water alone. When the surface of the roadway becomes rough and rutty by the passing of wagons, the ruts and low places hold the water and prevent its passage into the side ditches, and although *these ditches* carry most of the water which falls, there is often *enough left in the* roadway to create deep mud and produce much harm. In Spring the frozen ground prevents the water from passing downward into the soil, and it remains to form mud on the surface.

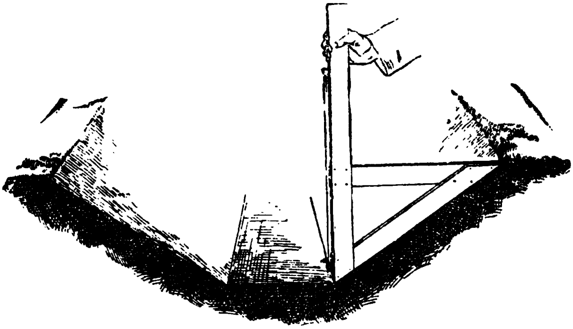


FIGURE 4. SHOWING HOW THE DITCH GAUGE IS USED.

The bottom of the ditch may be from six inches to one foot wide. The gauge is provided with a plumb line, fastened to the upright strip, as shown in the figure, and by this means the upright piece is held vertical and the slopes made to correspond with the edge of the diagonal strip.

Side ditches should be kept clear of weeds, grass, brush and all sorts of material that will tend to clog the ditch and stop the flow of water. They should be regularly examined and the greatest care taken not only to keep the ditches open, but a free and

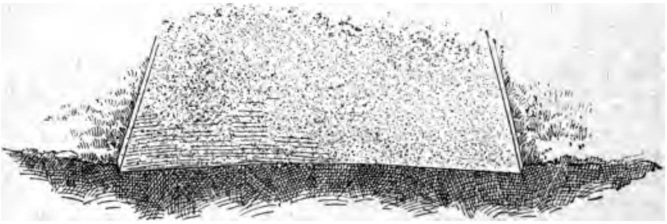


FIGURE 5.

Showing common form of country road, made by the use of a road machine or "grader." The blade of the machine may be set at any desired angle, and when drawn along by horses it cuts into the rough surface, and moves the dirt from the sides toward the centre of the road, forming gutters at the sides, and distributing the earth uniformly along the traveled part of the road. The action of the blade is shown in Fig. 17. A good road machine should be used by every town, and when used diligently will save twice its cost in a single season.

unobstructed drainage from the roadway into the surface ditches should also be maintained.

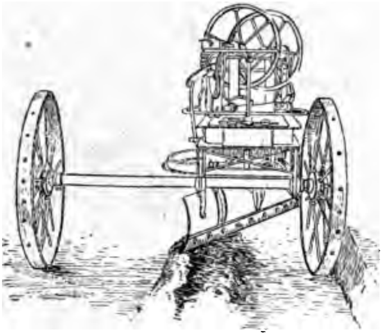


FIGURE 6.

Showing "angle ditch" at side of roadway being cleared and opened by the use of a road machine. These machines are great savers of time, labor and money, and will open ditches, clean out weeds and rubbish and give proper shape to a country road quickly and more uniformly than can be done by hand work.

Under Drains.—No way has yet been found of getting entirely rid of this mud, but nearly every dirt road can be greatly improved and a practically dry road obtained nearly the year round by the use of one or more lines of under drains. It is safe to say that there is scarcely a dirt road in the United States which cannot be so improved by under draining as to yield benefits to the farmers a hundred times greater in value than the cost of the drain itself.

Few people understand what a great amount of water is held by different kinds of soil. It has been found by actual experiment that a cubic foot of sand will retain from twenty-seven to thirty-two pounds of water; loamy clay, about forty-one pounds; stiff clay, forty-five pounds, and "humus" (soil formed of decomposed animal or vegetable matter), over fifty pounds. In other words, the weight of water in a cubic foot of humus, is more than one and eight-tenths the weight of the same earth in a practically dry condition, while the weight of water in a cubic foot of loamy clay is about one-half the weight of the entire cube. In most soils this water evaporates very slowly and we cannot prevent the formation of mud except by drainage.

Many miles of road are on low, flat lands and on springy soils, and thousands of miles of prairie roads are, for many weeks in the year, laid on a wet sub-soil. In all such cases, and, indeed, in every case, where the nature of the ground is not such as to insure quick drainage, the road may be vastly benefited by under drainage. An under drain clears the soil of surplus water, dries it, warms it and makes impossible the formation of deep, heavy, frozen crusts which are found in every undrained road when the severe Winter weather follows the heavy Fall rains. This frost causes nine-tenths of the difficulties of travel in the time of sudden or long continued thaws.

Examine the pictures on pages 2, 3, 4 and 10. Each of the roads shown in these pictures shows a variety of ailments, but the chief trouble in each case is a lack of drainage. Thousands of miles of these impassable roads may be found for weeks at a time in every state in the Union. Drainage is the fundamental necessity. There can be no good road without it.

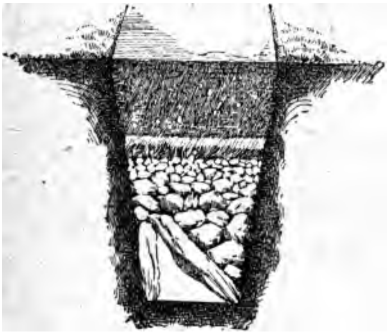


FIGURE 7.

Showing form of under drain made with field stones. The ditch is first dug and carefully graded at the bottom; then large flat stones are carefully placed at the bottom so as to form a clear passage of good size for the flow of water. The ditch is then half filled with rough field stone (with small sizes on top), and on these a layer of sod is placed with the grass side downward. The rest of the ditch is filled with earth. If sod is not to be had, fine brush, hay or straw may be used instead.

Under drains are not expensive. On the contrary, they are cheap and are easily made, and if made in a substantial way and according to the rules of common sense, a good under drain will last for ages. Use the best tools and materials you can get; employ them as well as you know how and wait results with a clear conscience. Slim fagots of wood bound together and laid lengthwise at the bottom of a carefully graded drain ditch will answer fairly well if stone or drain tile cannot be had, and will be of infinite benefit to a dirt road laid on springy soils. If the drain cannot be laid in the centre of the road without seriously interfering with the passage of wagons, the ditch can be dug on one side of the roadway and between the roadway and the ditch. It should not be less than four feet deep, and this depth will, in most cases, be about right. If we decide to use field stones, we *should select* flat ones to form the opening or channel at the bottom *of the drain*, and they should be laid with care, so as to leave a

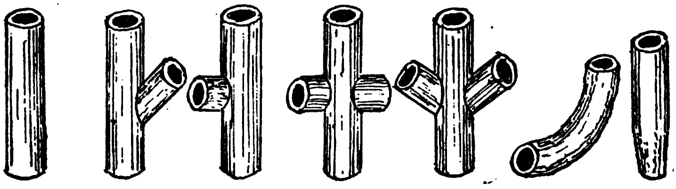


FIGURE 8. DIFFERENT FORMS OF DRAIN TILE.

good sized opening, as shown in Fig. 7. The method of building this drain is described briefly in the text under the figure.

How a Drain Works.—If we put a dry sponge in an open dish and place it outdoors in a heavy shower, the sponge becomes filled with water and we say it is "soaked" or saturated. If we then make a hole in the bottom of the dish, the water at once finds an outlet and a large part of it runs out; the sponge soon becomes lighter in color and lighter in weight and, if exposed to the sun, will quickly dry. Nearly every soil is made up of a large number of particles filled with pores and separated by very small channels, and these pores and channels absorb water just as the sponge does, and will hold it for a long time unless there is an outlet at the bottom through which the water may run out. This outlet is provided by an under drain. The water is heav

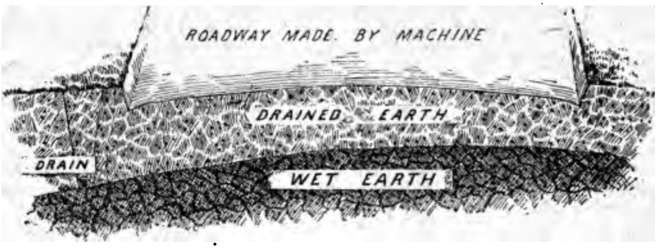


FIGURE 9.

Showing how the soil under the road is drained by an under drain. This figure shows the ordinary form of roadway made by a road machine, with no side ditches except the angle ditches formed by the blade of the machine. The drainage water is drawn out of the soil by the tile drain at the left and the top line of saturated earth is lowered to about the level of the tile. The drain may be put either at the side or the centre of the road. It works about the same in either position.

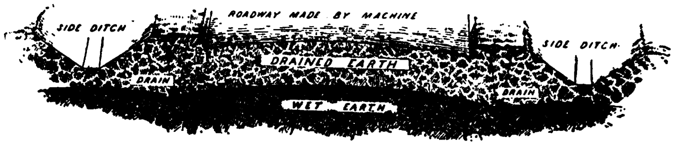


FIGURE 10.

Showing earth roadway made by a road machine, with side ditches and two under drains. Such a road is not expensive to make, and of all forms of dirt road is the cheapest and easiest to keep in good condition. Where only one under drain is used, it may be placed either under the centre of the road or on that side of the road on which the natural surface of the ground is the higher.

and limpid; its natural course is downward; it enters the drain tile through the openings between the different lengths of tile (the "joints") and runs along down the grade inside the pipe till it reaches the outlet. Each little channel between the particles of earth acts as a feeder to the drain and each drain will clear the earth of drainage water down to about the level of the tile. The water cannot leak out through the open joints of the tile because the earth below and at the sides of the tile is already completely filled with water and cannot contain more, and as long as the channel of the drain is not entirely filled with water, the soil will continue to empty its drainage water into the tile. Figs. 9 and 10 show the way in which an earth road is drained by one or more lines of tile laid at the side of the road.

Leveling.—The use of a simple "dumpy" level or drainage level is easily learned, and the roadmaker who can employ a level in his work is certain to have the best results. It will aid him in fixing and staking out grades for the roadway, for surface ditches and for underdrains, rapidly and accurately, and besides insuring a better and more permanent job, it will be a source of satisfaction to him in every branch of his work. The cheaper forms of levels sold by dealers in surveyors' instruments will generally answer every purpose. There is now in the market a special "drainage level" which, by an ingenious mechanical device, is made to indicate grade at each point of the ditch or roadway without requiring the road maker to "figure it out." The appearance of the grade level is shown in Fig. 11. The price ranges from $12 upward. Full directions for using the level is contained in a handbook supplied by the maker, and it is scarcely worth while to include them here.

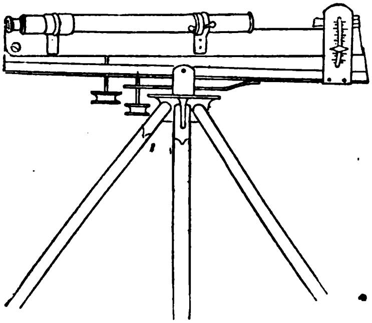


FIGURE 11. HARRIS'S GRADE LEVEL.

The Drain Ditch.—Before beginning to dig, lay out both sides of the ditch by two lines of stakes set 25 feet apart lengthwise with the ditch. Do this carefully. For a depth of four feet in stiff clay soils, a width of 16 to 20 inches at the top of the ditch will be about right if narrow drain tools are used. If any part of the ditch is deeper than four feet, widen the top in proportion to the increase of depth. Use sharp narrow spades for digging and cutting the sides of the ditch, and if you have much underdraining to do get a set of draining tools, or at least a ditching spade, a tile spade and a "draining scoop" or finishing scoop to use in shaping the bottom of the ditch to fit the tile. These, with a level and careful work, will be enough. If the sides of the ditch show signs of caving in, brace them with short pieces of board or plank and cross brace as shown in Fig. 14.

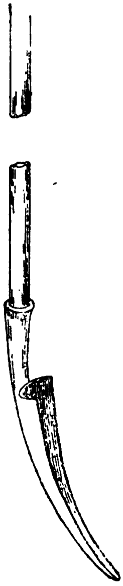


FIGURE 12.
Finishing scoop for shaping bottom of drain ditch to proper grade and of correct form to receive tile.

Begin at the lower or down stream end of the ditch so that water will run out as you go along with your work. Do not open too great a length of ditch at a time; put your tile in place as you go along and cover it. It will then help to keep the ditch dry and will make your work easier. Be very careful to keep an exact grade as you go along. A succession of humps and hollows will cause your drain to clog and will in time ruin it.

Grade of Drains.—If possible give the bottom of your drain ditch a fall of at least six inches for each hundred feet of length. A fall of three inches will carry the water, but with light grades extreme care must be used in forming the ditch bottom to exact grade in every part, and the lighter you make the grade the greater will be the danger of a sluggish flow of water and the clogging of the drain.

Size of Drain.—If poles, withes, or fagots are used (as they sometimes are when stone and tile are scarce or too expensive) they should be laid lengthwise in the bottom of the ditch to a height of not less than six or eight inches. The ditch should be six inches wide at the bottom and the poles, withes or fagots should be carefully covered with sod, with the grass side down, before the ditch is filled. If stone is used, select flat pieces to form the opening, and make the cross section of channel at least four inches in smallest dimension. If tile are used, the proper size will depend on the length of the drain and the condition of the ground. If the drain is long, the soil wet and "springy," and the grade light, a five-inch tile will be about right, and whether one or two lines of tile should be used must depend on the judgment of the road maker. Under ordinary conditions the following rule may be used:

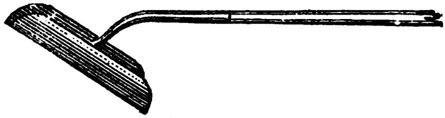


FIGURE 13.
Miles's improved draining scoop for removing earth from the bottom of the ditch and preparing a bed for the tile drain.

For drains not longer than 1,200 feet use a 3-inch tile.

For drains 1,200 to 2,000 feet long use a *4-inch tile.*

For drains 2.500 to 4,000 feet long use a 5-inch tile.

Remember the rule, that double the diameter gives four times the capacity. A four inch (round) tile will pass more than four times as much water as a two-inch tile, because it has an opening four times as large and an inner surface (which obstructs the flow of water by friction) of less than four times the inner surface of the two-inch tile. A three-inch tile will pass about thirty-five gallons of water per minute when laid on a grade having six inches fall per hundred feet. But a larger drain is never out of place in a roadway, and it is better in some ways than the smaller one. It admits more freely the warm air in Spring and hastens the thawing of the frost and the drying of the road.

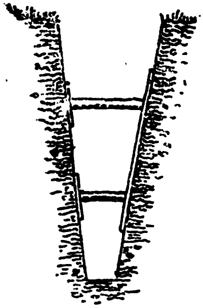


FIGURE 14.
Cross section of ditch with braced plank supports to prevent caving in.

Quality of Tiles.—Avoid soft, under-burned tiles, which can generally be detected by their pale color and by the soft, dead, "punky" sound given out when they are struck by a steel blade or hammer. They are likely to become softer when saturated by water, and to yield to the pressure of earth or become destroyed by frost. Avoid, also, over-burned tiles, which, though often extremely hard, are generally shrunken, more or less warped, and difficult to lay and to match joints one with another. Select straight, hard tiles of a strong, bright cherry color, and see that they give out a clear, ringing sound when struck by a trowel or piece of steel. All tiles should be assorted before using, and the least perfect pieces should be put in the up stream or inlet end of the drain.

Laying Drain Tiles.—If your drain fails in a single spot it fails entirely, and no drain is better than its worst laid tile. The grade cannot be guessed at or carelessly followed, and in most cases it will be best to employ a skilled ditcher to do the work. A taut line should be stretched lengthwise with the ditch and over its centre, and this line should be exactly parallel with grade of the bottom of the drain and about seven feet above it. This being done, Dr. Manly Miles, in his excellent little

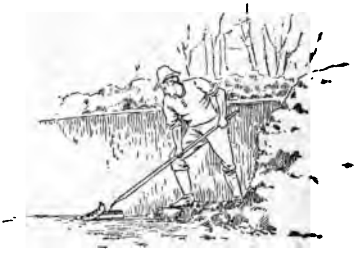


FIGURE 15.
Workman at work in drain ditch; taking out bottom with draining scoop and laying tiles as described in the text.

work on "Land Draining," * gives the following directions, than which the author can suggest no better:

"The ditch having been dug to within eight or ten inches of the bottom, and the line properly adjusted over the middle of the ditch, two men may begin the work of finishing the excavation and laying the tiles, which we will suppose are for a four-inch main, beginning at the outlet. A level-headed boy, or the proprietor as superintendent if he does not prefer to lay the tiles himself, will facilitate the work by managing the measuring rod, and performing any other service that may be required, from time to time, outside the ditch.

"One of the men standing in the ditch, with his face towards the outlet, with the six-inch draining spade, slices off the earth, or loosens it to nearly the required depth, moving backwards as the work progresses, while the tile-layer stands facing him and throws out the loose earth with a shovel scoop, or the draining scoop, Fig. 13, as may be most convenient. When the excavation has been finished for a distance of three or four feet, the tile-layer planes a groove in the bottom of the ditch with the draining scoop, to the required grade, as gauged with the measuring rod, and lays two or three tiles in it with their ends closely in contact, and covers them with five or six inches of earth, on which he then stands, packing it around the tiles as he proceeds with his work. The next section of the ditch is then prepared for three or four tiles by a repetition of the process of excavation—planing a groove for the tiles—laying them and covering with earth, to form a platform on which the tile layer advances, and the same routine is again repeated.

"By following this system, it will be seen that the feet of the workmen are not within eight or ten inches of the bottom of the ditch, the man with the draining spade standing on the earth to be excavated, and the tile-layer on his underdrained platform, as represented in Fig. 15, is exempt from the annoyances of mud and water that are usually associated with the work of draining. If the bottom of the ditch is soft, and water is running over it, the man with the draining spade will be standing in mud, which will interfere with his efficiency and the general progress of the work. This can, however, be obviated in a very simple way, that more than repays the extra trouble it involves. A one and one-half or two-inch pine plank about six feet long, and a little narrower than the bottom of the ditch, is laid down for him to stand on. Near the upper end of the plank a hole should be bored, in which a small rope is tied, its free end being thrown over the edge of the ditch to keep it out of the mud. With this the plank can be pulled back from time to time, as may be required."

Cost of Tile Drains.—Of course, no exact figures can be given to show the cost of laying under drains, since the expense will vary with the cost of labor, the difficulties of digging, the size of tiles used and other items; but as an approximate guide I will say that a line of three-inch tiles can be laid four feet deep for about $5 per hundred feet, including cost of tile, laying, digging and filling. Four-inch tiles can be laid for about $5.50 and five-inch tiles for about $6 per hundred feet. With good management these figures are ample and in many cases they can be considerably reduced.

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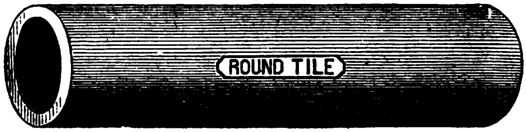
*Published by Orange Judd Company, New York, 1892.

Form, Cost and Capacity.—On another page of this chapter we have two tables which may be convenient. The first is about the average price list of hard burned tile and the second gives the carrying capacity in gallons per minute of the different sizes. One important thing we must remember in the matter of this price list. These are the average prices advertised by the manufacturer in his printed circulars, or, in other words, they are "list" prices, and when we buy we must insist upon a very substantial discount from these prices and feel very sure of getting it.



Drain tiles are made in different forms. The round tile is generally the best, though some people prefer a form known as "sole tile" because it has flattened upper and lower surfaces. This advantage is more imaginary than real, as the round tile is more easily fitted, end to end, and besides this the round tile is always lighter, less bulky and can be carried about at less expense and with less labor. The price of the two is about the same.

If we decide to lay our under drain along the centre of the road, we may, if a good quality of gravel is found in the neighborhood, get a very good roadway by following the plans shown in Fig. 19 in which the method of construction is briefly described under the figure. If no gravel is found, and the earth is of a clayey and sticky kind, we may follow the plans shown in Fig. 20. These forms of construction will be referred to again.

Notes in Brief.—Under drains take only the heavy surplus water from the soil—the "drainage water;" they prevent the formation of heavy frost in the road and warm and dry the earth about and above them.

They do not take water from the ruts and holes in the road. The surface becomes "puddled" by the action of horses' feet and wagon wheels and low spots and ruts in the surface will hold the water until evaporated or carried off into the side ditches.

It is a common belief that drain tiles should be covered with loose stone, sod, brush or other porous materials, but this idea, among drainage experts, has been long since exploded. It is sometimes necessary to cover the joints with tarred paper or clay, to prevent the flowing in of silt in quick-sandy places; but in firm soils it is sufficient to fit the joints closely together and pack the earth closely against the top and sides of the tile.

The manufacture of drain tiles should be encouraged. The business is a profitable one; the plant required is not expensive; the operation is not difficult and any clay that will make good bricks may generally be relied upon to make good tiles.

PRICE LIST OF HARD BURNED FARM DRAIN TILE.

Size.	Area in Inches.	Weight per Foot.	Price per 1,000 Feet.	Curves and Reducers, Each.	1 Foot Branches, Each.	2 Foot Branches, Each.	No. Feet to Car Load.
2..........	3.141	3	$ 20.00	$ .20	$ .30	....	8000
3..........	7.068	4½	30.00	.20	.30	....	6000
4..........	12.566	6½	45.00	.25	.30	....	4000
5..........	19.625	9	60.00	.30	.40	$ .50	3000
6..........	28.274	12	80.00	.40	.50	.70	2200
7..........	38.484	15	110.00	.50	.70	.75	2000
8..........	50.265	22	150.00	.70	.75	.90	1250
9..........	63.617	26	200.00	.75	1.00	1.00	1000
10..........	78.539	33	250.00	1.00	....	1.15	850
12..........	113.09	44	325.00	1.25	....	1.25	750
15..........	176.71	60	450.00	1.50	....	2.00	500
18..........	254.46	92	700.00	2.25	....	2.50	350
20..........	314.16	106	1000.00	3.00	....	4.00	250
21..........	345.00	110	1250.00	4.00	....	5.00	225
24..........	452.39	150	1625.00	5.00	....	6.50	200

CARRYING CAPACITY, GALLONS PER MINUTE.

Size of Pipe.	1 Inch Fall per 100 Feet.	2 Inch Fall per 100 Feet.	3 Inch Fall per 100 Feet.	6 Inch Fall per 100 Feet.	9 Inch Fall per 100 Feet.	1 Foot Fall per 100 Feet.	2 Feet Fall per 100 Feet.	3 Feet Fall per 100 Feet.
2 inch	6	9	13	19	23	27	37	46
3 inch......	13	19	23	35	40	46	64	79
4 inch......	27	38	47	66	81	93	131	163
6 inch............	75	105	129	183	224	253	364	450
8 inch......	153	216	265	375	460	529	750	923
9 inch............	205	290	355	503	617	711	1206	1240
12 inch......................	422	596	730	1033	1273	1468	2076	2554
15 inch......................	740	1021	1282	1818	2224	2464	3617	4467
18 inch......................	1168	1651	2022	2860	3508	4045	5605	7047
20 inch....	1560	2054	2450	3450	4180	4860	6850	8410
24 inch........	2376	3281	4152	5871	7202	8803	11714	14466

III.

IMPROVING THE SURFACE.

GRADES; HOW THEY AFFECT HAULING—GRADES SHOULD BE MADE EASIER AS SURFACE IS IMPROVED; ROAD SURFACE SHOULD BE SMOOTH AND HARD—PLOUGHING TO BE AVOIDED—ROAD MACHINES RECOMMENDED; HOW TO SELECT AND USE THEM—CARE OF ROAD MACHINES—WIDTH OF THE TRAVELED ROADWAY—FORM OF CROSS SECTION—ROLLING AND ROLLERS—WHEEL TIRES—THE EARTH IN THE ROADWAY—GRASS AT THE ROADSIDE—SIDEWALKS AND SHADE TREES.

THE difference between a good grade and a bad one is largely the difference between walking and climbing—between drawing a wagon and lifting it. The better the road surface is, the better the grade should be, because the force of gravity, or down hill "pull," on a steep grade is harder to overcome on a smooth, hard surface than on a soft one. On an ordinary earth road in fair condition it takes two horses to haul up a grade of nine feet in a hundred, the same load that one horse can haul on a level; while on a good macadam road the same force that will haul a load on a level surface is only about one-fourth the force required to haul the same load up the nine foot grade.

This statement must not be distorted into an argument against the macadam road, for we must remember that a horse can generally haul three times the load on a good macadam road that he can haul on the best earth road that can be made. Of course we know that for short distances a horse can exert double his usual effort in hauling loads up steep grades; but in any case the size of the load is limited very greatly by the steepness of the grades and so these grades should always be lightened as much as possible. We find so many different kinds of surfaces on different roads that it is impossible to give figures that will be an exact guide in all cases; but I will print here two short tables giving results obtained by experiment, and to these results the grades on all roads will bear a proper relation. Here is a table showing how, on à given road surface, the hauling power of a horse is taxed by an increase of grade. If the horse can haul 2,000 pounds on a level, then in going up hill he will be able to haul as follows:

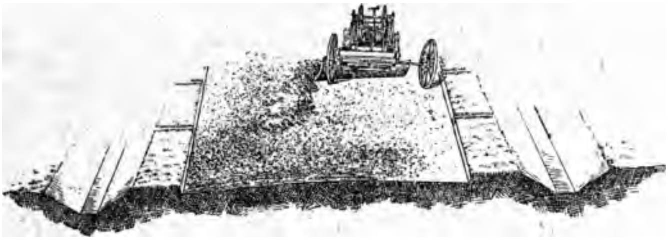


FIGURE 16.

Showing proper form of country dirt road. There may be only one side ditch when space is scant, but two are always better. A strip of sod three feet wide runs along between the ditch and roadway. The roadway may be from eight to fifteen feet wide, according to the amount of travel, and is connected with the side ditches by short drain ditches, running across the grass strip at frequent intervals. The figure shows a road machine employed in repairing the roadway.

On a rise of one foot in 100, the horse can draw only 1,800 pounds.
On a rise of one foot in 50, " " " " " 1,620 "
On a rise of one foot in 40, " " " " " 1,440 "
On a rise of one foot in 30, " " " " " 1,200 "
On a rise of one foot in 26, " " " " " 1,080 "
On a rise of one foot in 20, " " " " " 800 "
On a rise of one foot in 10, " " " " " 500 "

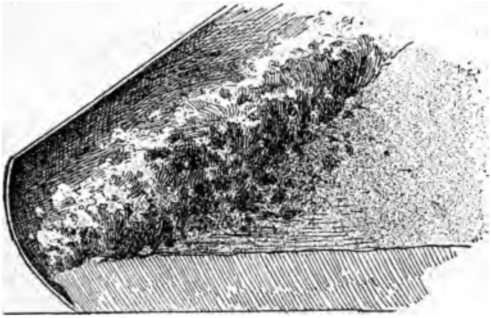


FIGURE 17.

Showing manner in which the earth in the country road is "graded" and moved by the action of the blade of the road machine.

The following tables, prepared by Prof. Wm. W. Carson, of the University of Tennessee, are interesting and instructive.

This table shows how many times as heavy a load a horse can draw, without extra effort, as on a level earth road:

RISE PER 100 FEET.☞	0	3	6	9	12	15
Earth Road.............	1.00	.75	.60	.50	.43	.37
Gravel Road............	1.39	.95	.72	.58	.49	.42
Macadam Road.........	3.13	1.52	1.00	.75	.60	.51
Telford Road...........	4.35	1.75	1.11	.81	.64	.53
Plank Road..............	4.76	1.85	1.14	.83	.65	.53
Stone Trackway........	16.67	2.50	1.37	.93	.71	.58

This table shows how many times as heavy a load a horse can draw, without extra effort, as on a level road of its kind:

RISE PER 100 FEET.☞	0	3	6	9	12	15
Earth Road.............	1.00	.75	60	.50	.43	.37
Gravel Road............	1.00	.68	.52	.42	.35	.30
Macadam Road.........	1.00	.50	.32	.24	.19	.16
Telford Road...........	1.00	.40	.26	.19	.15	.12
Plank Road.............	1.00	.38	.23	.17	.13	.11
Stone Trackway........	1.00	.17	.09	.06	.04	.04

Surface Should be Smooth and Hard.—The surface of the road should be smooth, for smoothness means easy hauling. The surface of the road should be hard, for hardness prevents the formation of ruts and the sinking of wheels into the surface. Besides, a hard road surface will shed water quickly, and if water is quickly carried off, the roadway will be kept dry, and the formation of mud holes avoided.

Until within the last few years we have known no way of "working" the country road except the old shiftless, slip-shod method of tinkering, in which the farmers have contributed their half-hearted labor, and have mauled and ploughed and hoed and scraped and pawed the earth into all sorts of senseless shapes in settlement of the road tax, and the chief reason why the dirt road has seen no improvement for five hundred years is because no uniform system of work has been followed and no machinery devised to do the work quickly and in a workman-like and systematic way.

In the light of modern invention this excuse no longer exists, and we now have a means of carrying the dirt from ditches toward the crown of the road and distributing it in a smooth and uniform manner, so that the rain water is carried from the centre into the side ditches and the wagon tracks may be kept comparatively dry.

A plough should not be used in working a dirt road except when actually necessary, because a ploughed surface is difficult to make smooth and hard, and the plough is likely to cut too deeply into the earth. We should, by all means, have a good road machine, if possible. These machines are sometimes called "scrapers" and sometimes "graders." There are several different forms of road machine in market, and nearly all of them are good. A good road machine will do the work of twenty laborers, and when put to its best, it will do the work of forty. Besides, it will be done uniformly and thoroughly. The best time to use a road machine is when the road is not too dry, and the best way to use it depends upon the machine we are using. Each manufacturer aims to get the best work out of his machine, and to use it so as to give the best satisfaction to the buyer. He will tell us how to use it to the best advantage, and by following his directions as closely as possible, we shall be sure not to go far astray.

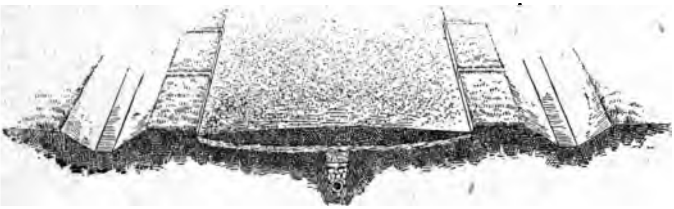


FIGURE 18. A CLAY OR HEAVY DIRT ROADWAY WITH UNDER DRAIN AT CENTRE.

When gravel or sand cannot be obtained, the improvement of a clay road is sometimes difficult. A good under drain may be laid along the centre of the road and the earth removed from the roadway to a depth of about one foot at the centre, from which point the excavation should rise by a gradual slope to each side. On the bottom of this excavation a layer or bed of hay, straw or coarse grass should be laid to a depth of about four inches (when compacted), and the earth should be then filled in and formed to the true shape of the roadway. This method of treatment will tend to keep the roadway dry and prevent the formation of mud.

The following points taken from the printed instructions sent out by one of our leading road machine companies, will be found generally useful:

SUGGESTIONS TO OPERATORS AND POINTS TO BE CONSIDERED IN SELECTING A ROAD MACHINE.

"To the fair-minded, intelligent road official of the present day, there is no question as to the many advantages of road machinery over any other method of repairing dirt roads.

Besides doing the work at less than half the cost, vastly better *results are obtained.* The difference between the results obtained *y the use of a road* machine and the old-fashioned plough and shovel method is clearly defined. A road machine of recognized, merit, will plough an even ditch of uniform depth, and will plough where an ordinary plough will not enter the soil. The scraping blade of the machine moves the earth from the ditch to the middle of the road, distributing it evenly and leaving the road-bed smooth, without any of those little bumps and holes which characterize a road repaired in the old-fashioned manner. These bumps and holes, small at first, will wear larger, and soon develop into good-sized ruts, making the road very unpleasant to travel over.

It is conceded that a good reversible machine will do the work of from thirty to forty men in the ordinary work of road construction, thus effecting a saving of more than one-half over the old methods.

Suggestions to Operators.—In the work of operating a road machine, as in everything else, experience is the best teacher. * * Machines are so simply constructed that any man, with ordinary intelligence, after he has acquainted himself with the different adjustments, will, with a very little practice, be able to operate the machine well under all circumstances. A slow, strong motion is indispensable to good work.

Repairing.—A little timely work done in the right way is like 'the stitch in time that saves nine.' No matter how nicely and well a road has been made, travel, rain and frost all combine to destroy it.

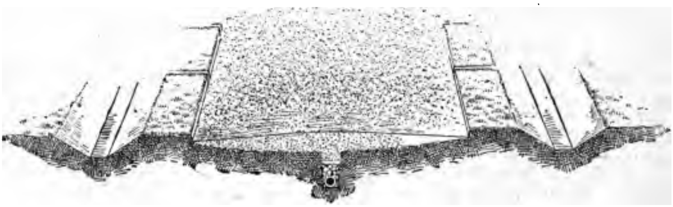


FIGURE 19. A GRAVEL ROADWAY WITH UNDER DRAIN.

When clean gravel of good quality is used, this makes a very excellent form of country road. The centre drain may be either of field stone or tiles, and is made as already described in Fig. 7. The gravel should be clean and "sharp" so as to pack and drain quickly and should contain very little soft earth, which always holds water and forms mud. A gravel road is always improved by keeping the surface in proper form and by rolling with a heavy roller.

There is hardly a month in the year when the road machine cannot be used to advantage in the road, but Spring is the best time to do efficient work, because the soil is loose and roots of grass and weeds do not interfere. Every Spring, before the *ground* becomes too hard, the road should be gone over thoroughly with the road machine; the ditches cleaned out, so that water may have a free outlet; ruts and holes filled, elevations in the road and the shoulders on the side of the road planed off, the grade improved and the road put in a good condition generally. In repairing a road which is in fair condition, commence at the ditch and work towards the centre, scraping lightly with the entire length of the blade, till the last rounds in the middle of the road, when the rear end of the blade is carried high enough to allow the earth to distribute under it. To make the blade penetrate very hard, stony ground, it may be best to use only the point, elevating the rear end considerably. The best finish can be obtained in sod ground by first cutting the sod as thin as possible, then placing them in the middle of the road, and finally going back to the ditch and bringing up earth and leveling over the sods. Ruts or depressions that are too deep to be filled with the machine, should be filled in with gravel. Do not fill in more than is necessary; only sufficient to fill the holes.

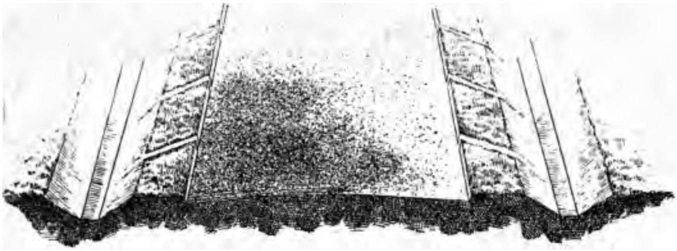


FIGURE 20.

Showing method of surface drainage where the road runs down hill. The short ditches connecting the roadway with the side ditches are made with a diagonal pitch down the grade so to catch the running water in the roadway and carry it to the side ditches.

How to Build New Roads.—In building new roads with a machine, first mark out your ditches the full width, ploughing a light furrow with the point of the blade, carrying the rear end well elevated. On the second round, drive the wheels in line with the point along the hollow made the first round, ploughing a full furrow with the advance end of the blade, dropping the rear end somewhat lower than before. The third time round move over towards the middle of the road the earth previously ploughed. Then return to the ditch and plough it out deeper, moving the earth towards the middle whenever as much earth is ploughed as the machine can move at once. Repeat this until the ditches are *the proper depth*, and the road as full and round as required; then *surface off* as directed in repairing.

Points to be Considered in Selecting a Road Machine.—In the selection of a road machine, the following points should be carefully considered:

1. Thoroughness and simplicity of its mechanical construction. 2. Material and workmanship used in its construction. 3. Ease of operation. 4. Lightness of draft. 5. Adaptability for doing general road work, ditching, etc. 6. Safety to the operator."

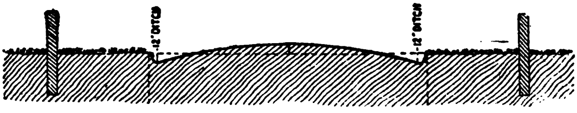


FIGURE 21.

Showing cross section of common form of country road made by a road machine in soft soil. The 12-inch ditch is provided to catch and carry off the surface water and the ample "crown" given to the road makes due allowance for settling and insures quick drainage of water from the surface. Under drains and side ditches would greatly benefit this road in many localities.

One of the most agreeable things in the use of a road grader is the fact that each time the grader is used the work becomes easier, better done, more satisfactory and better in appearance. If used frequently, the roadway will have a shapely and attractive look, the ruts will be kept out of it and the wheeling will be easier for all who use it. In making repairs it is best not to wait till the road becomes dry before putting the scraper at work. The best time to begin is when the road is just so dry that the mud will not stick to the blade of the grader but will "discharge" easily. This will occur when the earth is still quite moist, and in working the grader at this time we shall avoid dust, besides spreading the loosened earth into the roadway at a time when it will pack easily under the wheels of passing wagons. In making these repairs we begin at the angle ditch and set the blade so as to shave off the rough surface, fill the ruts and plane the roadway down to a *hard face.* The blade will carry the loose earth over toward the

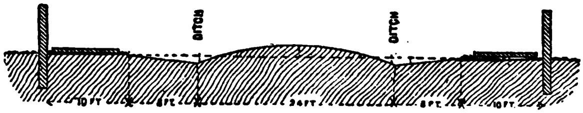


FIGURE 22.

Showing cross section of a sixty-foot street made by a road machine in a town or village. The ditches are given good capacity with gradually sloping sides, and are removed from the edges of the sidewalks for the reasons and in the manner described in the text.

centre of the road and as the passing wagons will naturally seek the smooth sides of the roadway, the material spread at the centre will have time to settle and become hard as the traffic is gradually brought over it.

A good reversible road machine with two or three teams and two men will repair from three-quarters of a mile to a mile of road a day, depending of course on the width of road and the amount of earth to be moved. A conservative estimate shows that to do the same work in the old-fashioned way will require a plough, two teams, and at least forty men.

The cost of three teams and two men to work the machine is about ten or twelve dollars; add to this the cost of one or two men who can be used to advantage in picking loose stones and rubbish from the road, and we bring the cost of building from three-quarters to a mile of road with a machine to $15. The cost of forty men and two teams is in the neighborhood of $55, so that the balance in favor of the machine is $40. This is the comparison of cost. A comparison of the results obtained by the two methods is still more favorable to the use of the machine. The scraping blade of the machine cuts an even, uniform ditch, and will plough where the ordinary plough cannot be made to enter the ground. The earth is carried to the centre of the road and distributed evenly, leaving no little holes and bumps, so common in roads built with plough and shovel. These little bumps and holes are detrimental to good drainage, besides making the road very unpleasant to travel over. The wide tires of the machines and the constant tramping of horses hoofs backward and forward as the road is being constructed tends to solidify the road-bed.

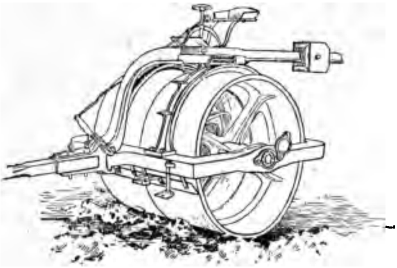


FIGURE 23.

The "Austin Reversible" horse roller. Weight, from 3½ to 8 tons. Diameter of roller, 4½ to 6 feet, producing pressure of 235 to 270 lbs. per lineal inch. Provided with anti-friction roller bearings to lighten draft and weight-plates for increasing weight.

Anyone who has compared the road built by the old-fashioned method, with its rough, uneven surface, with the clean ditches, and smooth even surface of a road built by the machine method by a good operator, will not hesitate long in passing judgment on the two methods. A road machine can also be made very useful *in the work of* under drainage, where side drainage is considered *incomplete.*

The purchase price of a standard road machine varies from

$200 to $250, and considering that these machines must be built of the best material and in the best possible manner, in order to stand the strain incident to this class of machinery, the price is very reasonable.

The cost of maintaining a machine is but a trifle. An edge or shear is generally attached to the main scraping blade, and when worn out can be renewed.

The edge costs but $8, and towns seldom use more than two edges a year; many towns not more than one. The work of operating the machines is very simple. Road machines have reached such a state of perfection that any man of ordinary judgment can operate them. Of course the more knowledge the operator has of the principles of road making, the better road will he construct.

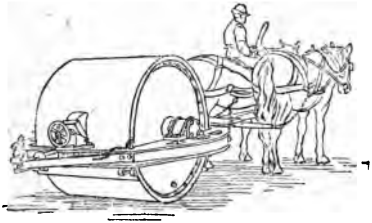


FIGURE 24.

The "Addyston Reversible" horse roller with solid heads. The weight is increased by filling the roller "drum" with water, and the water is drained out when not needed. Total weight, 8 tons. Roller bearings at axle to lighten draft.

Many people have the mistaken idea that a road machine cannot be used except on a road that is comparatively free from stones. This is a mistake, as in no section of the country are road machines more generally or more effectively used than in the New England States, where stone is almost as plentiful as dirt.

Road machines can be used to good advantage on macadam or telford roads in scraping up dirt and rubbish into winrows to be carted off. They are also used by street car companies in scraping snow from tracks, and for this purpose special wheels are constructed to gauge to street car tracks. They are also used in building lateral ditches for drainage on farms and plantations. And again, road machines are found to be very useful in cleaning gutters, in cities and large towns, of ice and slush.

The best results can be obtained by placing a road machine in each road district, under the charge of the officer in that district, who is responsible for the care of the roads. The road districts should not be too large nor too small. An ordinary sized western township should be divided into six road districts and a machine given to each one. The road official of that district, whether called supervisor, overseer or pathmaster, should have authority to purchase machines and obligate the district to pay for the same, and he should also be required to operate the machine, since nearly all of the road work can be done by the machine, and he cannot earn his wages except in its operation. The labor of operating a machine is so light that very few overseers, or supervisors, will object to that requirement.

Taxes should be paid in cash, so that teams most suitable for the work can be procured by the responsible officer and the same team can be used from day to day instead of changing teams several times a day, as must generally be done where the taxes are paid in labor. Many of the western states are adopting this view of the matter, and there is little doubt that provision will soon be made for payment of all taxes, except "poll taxes," in cash. By properly using these machines the roads can be put in such shape that a very little work in the Spring after the frost goes out (repeated occasionally as heavy rains make it necessary), will keep the roads in good condition for ordinary country travel and traffic. It is of course true that in very wet years there will be times when it will be difficult to haul large loads, but a road well made and well drained is passable for teams at all times.

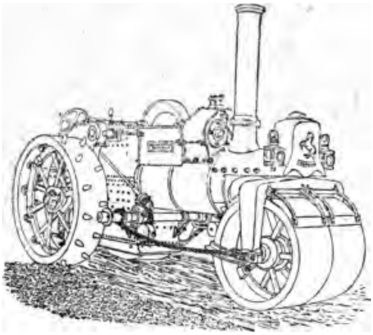


FIGURE 25.

The "Aveling and Porter" steam roller. Weight, 10, 15 and 20 tons. Pressure per lineal inch, 450 to 650 lbs. Diameter of driving wheels, 5½ to 6½ feet. Crucible steel gearing throughout.

The saving in the expense of making and keeping in repair the earth roads by the new methods will enable the people to gradually build permanent roads without increasing the taxes which they are accustomed to paying. When this is once demonstrated the public will be very willing to apply its funds to the best advantage. The benefits they will receive from good earth roads will lead them to earlier adopt plans for securing hard and permanent ones.

Care of Road Machines.—All the tools, implements and machinery belonging to a town or road district should be placed in charge of a careful and responsible officer who should be held accountable for their good condition. A storage house should be built to contain this property of the town or district and made secure with lock and key at all times when the tools are not in use. The house should be on well drained ground and a dry floor should be provided to save damage from rust. The road grader, when not in use, should be thoroughly cleaned, its blade brushed free from all accumulations of mud, wiped thoroughly dry and well covered with grease or crude oil. All axles, journals and wearing parts, should be kept well oiled when in use and the blade or "share" should be kept sharp and in good condition at all times. A little precaution in this respect will insure cleaner and more effective work and will doubly pay for the care given it. It will pay in most cases to have an extra blade or share, so that the work of the machine need not be stopped while one of the blades is being sharpened.

Width of Traveled Roadway.—The traveled part of the road should be of uniform width, and the two sides should be parallel, if possible. Sometimes a width of ten feet will be enough; but sixteen feet is about right where much travel is to be provided for.

In some parts of the country where the width of highway (between fences) has been fixed at forty feet or more, the road maker is often tempted to make the wagonway eighteen or twenty, and in some cases even twenty-four feet wide, but unless special reason exists in certain localities, it is a waste of time and labor to construct this extra width and a perpetual expense to keep it in repair. In the vicinity of large towns where the wagon travel is great, and in approaching railroad stations where much hauling is done, it may be necessary to make the width greater than eighteen feet, but in most cases where the traffic is so important as to require an increased width, it will be good economy to abolish the dirt road and substitute a substantial paved or macadamized roadway, even at a round figure of cost.

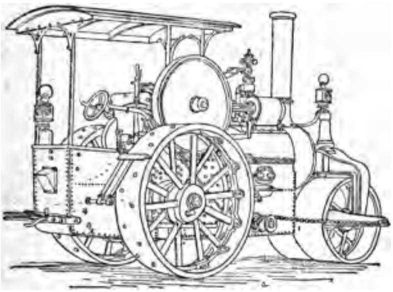


FIGURE 26.

The "O. S. Kelly Company's Springfield Steam Roller." Weight, 10, 12½ and 15 tons. Diameter of driving wheels, 6 feet. Pressure per lineal inch, 500 to 600 lbs. Double speed gearing and wide face fly-wheel for driving a belt when required.

Cross Section.—The cross section of the wagonway should be made with a substantial rise from each side to the centre, and the amount of fall from the crown of the road to the bottom of the angle ditch must depend on the nature of the soil and the width of the roadway. If the soil will settle and pack quickly allowance must be made for this, and the crown of the road should be higher. It should always be higher in earth roads than in macadam and telford roads, because the drainage of a dirt surface is more sluggish and the steeper cross section is needed to quicken the flow of water into the side ditches. In some cases a slope of one inch in twelve from side to centre is too much; in other cases it is not enough. Follow this rule: Keep your angle ditches clear and clean, and your roadway smooth, and give it slope enough from centre to sides to quickly carry surface water to the ditches.

Do not make the surface too "rounding" from side to side, but try to make each side in the form of a sloping plane, and at the centre of the road, where the two slopes join, round off the apex slightly. The angle ditches at the side should have a good depth, and in soft soils a depth of twelve inches will be about right. Fig. 21 shows the common form of cross section of road made by a machine, and this form is excellent, as far as it goes, but without surface ditches and under drainage it would in many cases be condemned as cheap and faulty. These shallow gutters or ditches become easily clogged by passing wagons and by loose dirt. They are not large enough to contain and carry off all the water of heavy rains and melting snows, and for this reason the surface ditches described in the preceding chapter should not be omitted. These surface ditches should be connected with the roadway by narrow surface drains placed about ten yards apart along the line of the road, and on all steep grades these narrow drains should run diagonally downward from the roadway to the surface ditch, as shown in Fig. 20. If made in this form, they will catch the water easily as it runs down the hill and carry it quickly into the side ditch where it properly belongs.

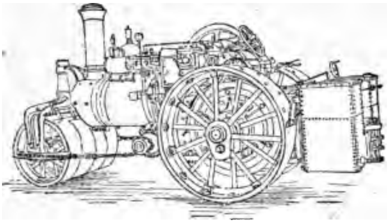


FIGURE 27.
The Harrisburg "Double Engine" steam roller. Weight, 10, 12 and 15 tons. Pressure, 466 to 566 lbs. per lineal inch. Driving wheels of varying dimensions as best adapted to the work required.

Sometimes the roadway space will be found too narrow to admit of the making of side ditches, and in such cases, and indeed in every case, the road machine or grader should be used frequently to clear out the angle ditches at the side of the wagonway, so as to keep them clear of loose dirt, weeds, brush, etc. The best way of doing this will be found in the printed instruction received from the manufacturer, and it will be sufficient to say here that the cutting edge or angle of the scraper should be so pitched (in cutting the angle ditch) as to cut a clean furrow of uniform depth and carry the loosened earth toward the centre of the road. By the frequent use of the road machine, the wagonway will be kept smooth and in proper shape, the ruts filled as fast as they form, and the drainage so improved that the roadway will dry quickly after each shower and mud holes will become practically unknown.

In small towns and villages the objection of property owners to *having gutters* near the sidewalk may be avoided by adopting the form of cross section shown in Fig. 22 which shows the section of a sixty-foot street. The ditch or gutter on each side is eight feet from the edge of the sidewalk space, and each ditch is given ample capacity and depth (without the steep sides which are always objectionable and sometimes dangerous), by carrying a gradual slope to the sidewalk and to the centre of the road from the bottom of each ditch. "This will afford good drainage to the whole side of the street, giving ample driveways, and leaving the sides of the streets in shape for approach of vehicles to the sidewalk without compelling the animals attached to stand in the mud and water of the gutters. On streets less than seventy feet wide, make the gutters ten feet each side of the centre of the road, for the reason that shade trees are usually planted outside of the sidewalks and it is better to make the centre driveway narrower than to crowd the gutters too close to the sidewalks and trees. When it comes to crossings the gutters can be deflected or carried along on a straight line." *

Rolling.—Every road is made smoother and harder by rolling, and dirt roads are no exception to this rule. We have all noticed that the hardest and smoothest parts of a country road are the narrow strips which mark the passage of the wagon wheels that have gone over it, and these parts have become hard and smooth because the wheels have acted as rollers. But a wagon wheel is not always a very satisfactory roller, for the reason that the wheel tires are too narrow, and when the road is wet and soft the narrow wheels sink into the surface and form ruts and cut and mix and mangle the dirt out of all reason, and destroy the good qualities of the roadway. If all the wagons used on country roads could be provided with tires four inches wide, they would roll the surface more smoothly and more quickly, and it would be in fairly good condition for nearly the whole year round. A good horse roller will serve much to cure this difficulty, and such a roller can be bought for from eighty to one hundred dollars per ton. A roller weighing about five tons is about the proper thing.

Steam rollers are becoming more generally used from year to year in our cities and towns and there are many places where they can be used to advantage in consolidating the earth roads of the suburbs. They are generally more effective in their work, and if kept busy are vastly cheaper to operate. They weigh from seven or eight tons upward, the ten and twelve ton sizes being perhaps the most popular.

Rolling should follow closely upon the work of the road grader or scraper, so as to consolidate all the loose earth which the action of the scraper has laid in the line of the roadway. The roller should pass many times over the softer portions of the road, and where the road is very dry and not inclined to pack, it may be slightly moistened to hasten the action of the roller. The rolling should begin at the sides of the road and work gradually towards the centre, that is, the roller should be passed from end to end along the side of the road, and then the second passage of the roller should slightly lap the first, until the centre of the road is reached.

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* For much of the valuable information contained in these pages regarding the use of road machines, the author is indebted to the kindness of the F. C. Austin Manufacturing Co., of Chicago, the American Road Machine Co., of Kennett Square, Pa., the Western Wheeled Scraper Co., of Aurora, Ill., and the *Climax* Road Machine Co., of Marathon, N. Y.

Wheel Tires.—When a skilled mechanic constructs a machine in which two separate parts are made to rub or roll against each other he gives to each a wearing surface of such form and size and makes it of such materials as will produce the least amount of friction, for friction adds to the cost of running and hastens the destruction of the machine.

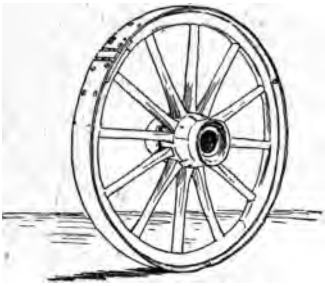


FIGURE 28.
The "Whipple" adjustable wide tire on wheel of ordinary farm wagon.

The road and the wagon are two wearing parts of the machinery of traffic, and every care should be taken to so adapt them to each other as to reduce the wear of each and add to the efficiency of both.

Whether a wagon tire should be broad or narrow depends largely upon the kind of road upon which we intend to use it. If the road is a continuous quagmire, the use of a broad tire will make travel more difficult without in any way benefiting the road; but if the road is to be kept dry by drainage and smooth by the frequent use of road machinery, the broad tire will act as a roller and will help to make the road instead of marring it.

A few years ago a number of tests were made by Professor Sanborn of the Missouri Agricultural College, to find the force or "draft" required to move loaded wagons having tires of different widths. The tests were made with a Baldwin recording dynamometer (an instrument for measuring force).

The weight of the loads drawn was 3,665 pounds each. The tires of the wheels were 1½ inches and 3 inches respectively. The test was made on blue grass sward partially moist, yet but little rain had fallen for twelve days. The draft of the wide tires averaged for level ground 310 pounds. The draft of narrow tires was 439 pounds, or 41.6 per cent. more than the wide tires.

Assuming the wagon to weigh 1,000 pounds, then on the broad wheels 3,248 pounds of load would be drawn as easily as 2,000 pounds on the narrow tires, except the loss from the wheels cutting deeper under the heavier load. Again, the broad wheels in the trial did not injure the turf, while the narrow wheels cut through it—an important consideration. *The teamsters for use about the College Farm invariably choose the broad wheels.* They find that they are not nearly as liable to get stuck in soft places or during rainy times.

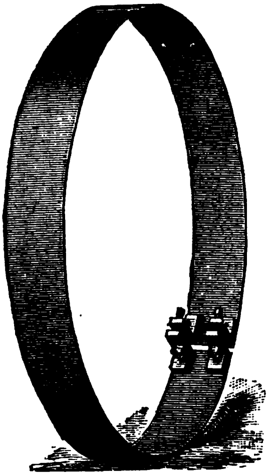


FIGURE 29.
The "Richardson" adjustable wide tire.

In a subsequent trial on a partially dried dirt road, the broad wheels cut the road less deeply and drew easier than the narrow wheels, the draft being for the broad tires 371 pounds, and for the narrow tires 441 pounds, or the latter drew 12.7 per cent. heavier than the former, a net difference per ton load of 381 pounds, or 381 pounds more could be drawn on the broad wheels to the preservation of the roads, as is recognized in two or three states by adjusting the rate of toll to the width of wheels, the toll being remitted on wheels of a certain width.

In 1892 another series of tests were made at South Bend, Ind., by the officers and skilled mechanics of the Studebaker Bros. Manufacturing Company. The results of these tests were carefully compiled and afterward published in a pamphlet, from which I quote some of the conclusions of the committee:

"You can haul 260 pounds more on a good, hard, sandy road with a 4-inch tire, with the same amount of power exerted, than you can with a 1½ inch tire.

"You can haul 505 pounds more on good, hard, sandy roads with a 4-inch tire with the same amount of power exerted than you can with a 1½-inch tire.

"You can haul 471 pounds more on level gravel roads with a 4-inch tire with the same amount of power exerted, than you can with a 1½-inch tire.

"You can haul 110 pounds more on level gravel roads, with a 4-inch tire with the same amount of power exerted, than you can with a 1½-inch tire."

The committee having in charge these tests states its conclusions that "on ground that a narrow tire would cut through, and a wide tire would not, the wide tire shows to the greatest advantage * * These are good tests for the farmer and show how easily he can overload his team; as under these conditions (driving across fields) 650 pounds is a good dead pull and no team should do more than that for steady work. 2.29 tons across the fields with 650 pounds straight draft is a big load. While almost any good team can do more than this, you must bear in mind that if the field is uneven or soft, and 1,200 pounds dead pull is required, as we have found it would be, this means a load of 4.58 tons."

In France the wagons used by the merchants and farmers have wheel tires ranging from three to ten inches in width, the most usual width being from four to six inches. The large freight wagons (four wheeled) have tires rarely narrower than six inches and the rear axle is about twelve to fourteen inches longer than the front axle, so that the rear wheel tracks will lap the tracks made by the front wheels and so widen the space of roadway rolled by the wheels. Many other four wheeled vehicles in France are also supplied with axles of varying lengths. In Austria tires for wagons carrying 2½ tons are each 4⅓ inches in width and those for wagons carrying 4½ tons are about 6½ inches wide. In Bavaria the width of wheel tires is fixed by law as follows:

2 wheel carts with 2 horses, 4.133 inches.
2 wheel carts with 4 horses, 6.180 inches.
4 wheel carts with 2 horses, 2.596 inches.
4 wheel carts with 3 or 4 horses, 4.133 inches.
4 wheel carts with 5 to 8 horses, 6.180 inches.

Carts with more than four and wagons with more than eight horses are not allowed to use the road without a special permit from the authorities.

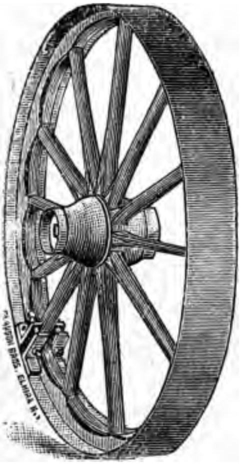
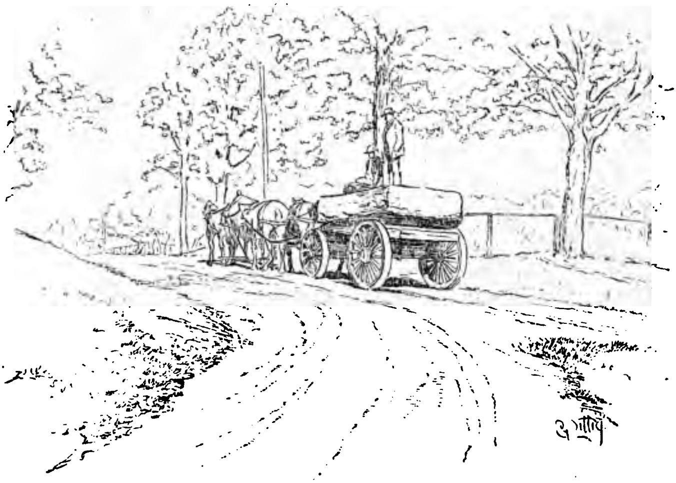

CLAYTON BROS. ELMIRA N.Y.

FIGURE 30.
The "Richardson" adjustable tire in place on wheel of a farm wagon

During the last three years (1890-91-92) a test of the use of wide tires in practical work has been made on the four and a half miles of road between Split Rock and the works of the Solvay Process Company, in Onondaga County, N. Y. Mr. Frederick M. Power (superintendent of the works and a member of the Board of County Supervisors) gave the writer the following statement regarding this test:

"The wagons were constructed in our own shops, and the wheels were furnished by the Archibald Wheel Works, of Lawrence, Mass. All wheel were of ordinary diameter. I built one wagon with wheels of following dimensions: Front tire, seven-eighth inch thick and four inches wide. Distance (gauge) between front wheels, four feet five inches. The rear wheels of this wagon had tires one inch thick and six inches wide, and the gauge or width between rear wheels was five feet eight inches.

I built another wagon with front tires five-eighth inch thick, and rear tires one inch thick; the front tires were four inches wide, and rear tires six inches wide; both these wagons had two and one-half front axles and three inch rear axles. A third wagon was considerably lighter. It had four inch tires, front and rear, with ordinary gauge in front and a gauge of five feet nine inches in rear. The axles, front and rear, were two and one-quarter and two and one-half inches respectively. All tires on this wagon were seven-eighth inch thick. These wagons were all "poled" for three horses, and the use of three horses tended to combine with the wide tires and varying gauges of front and rear axles, to smooth down even the slightest ruts caused by wagons of narrow tires and ordinary gauge, of which there were and are very many in use on this road.

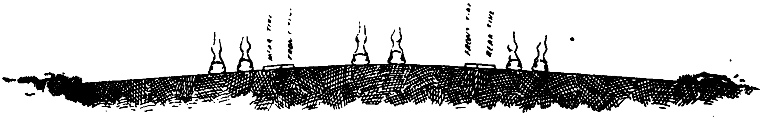


HAULING HEAVY LOADS ON WIDE TIRED WAGONS.

Three horses hauling load of over nine tons of stone (19.160 pounds) on road in Onondaga County, N. Y. Drawn from photograph in possession of the publisher.

"The constant use of three of these wagons during the last three years has produced a smooth, compact and regular surface between the quarry and our works, and the substantial crowning of the road has kept the surface well drained and, therefore, dry and free from ruts. These wide tires and varying gauges excited a good deal of attention at the outset, and conflicting opinions were expressed regarding their utility. The result is eminently in their favor, and the general sentiment has grown constantly in favor of the use of these wagons for heavy loads. We haul loads continually, varying in weight from 8,000 to 16,000 pounds, with no perceptible wear, weakness or breakdown either to the wagons or to the roads. The carts used at our works are varied in gauge and all have given excellent satisfaction in keeping the roadway smooth. When these wagons were first put into use the road was rough and rutty and the work of hauling was severe on the horses, but soon the broad tires began to roll and pack the road surface, and it it now difficult to exaggerate the great benefit these tires have produced in keeping the road smooth and hard and the amount of labor they have saved in the work of hauling and repairs.

"The cost of hauling stone has been reduced from 80 cents to 60 cents per ton, and a team can easily earn from $3.50 to $4.00 per day hauling wall stone and making two round trips of nine miles each, or a total of eighteen miles."



WIDE TIRES AND VARYING AXLE-LENGTHS.

Cross section of roadway, showing position of front and rear tires and tracks of three horse "team." The front tires are four inches wide and the rear tires six inches wide. The latter do not "track" in line with the front tires, but just lap them on the outside, as shown in the figure. This is accomplished by making the rear axle about eight inches longer than the front axle.

The Earth in the Roadway.—Clean gravel is always desirable, and should be used whenever it can be obtained. If the soil in the roadway is found to be of a sticky, clayey nature, we can improve it greatly by adding a few inches of sand and repeating this operation every few months as the sand works into the clay. If the soil is composed of loose sand, we can greatly improve the road by adding a layer of five or six inches of stiff clay.

In the first instance, the sand tends to counteract the stiff and sticky qualities of the clay, and in the second case the adhesive quality of the clay counteracts the looseness and shiftiness of the sand, and helps to stiffen it and hold it together. A little study and the application of common sense rules in each locality, aided by a few experiments, will generally enable us to arrange the clay and sand so as to give the best results.

Grass at the Roadside—Nine-tenths of the world judge from appearances. A country road can be made wonderfully attractive *proper attention* to its appearance. We have recommended that a space of about three feet in width be left between the edge of the road and the surface ditch on each side. This strip should be cleared of weeds and sodded, or sowed with grass seed, so that when finished it will have something of the appearance shown in Figs. 18 and 20. While not strictly necessary, this improvement gives a look of prosperity to the country, makes it attractive and inviting and adds to the value of surrounding property. In short, it is a good return for the little labor invested in bringing it about.

Side Walks.—In the Summer of 1893 the writer traveled over the country roads of France for the full width of the Republic from the west coast to the Jura Mountains, and though he saw hundreds of country people trudging along over the country roads on foot, he fails to remember a single side walk outside the limits of cities and villages. This means that if the roadway is made and kept as it should be, every man, woman and child can walk dry shod over the same path that is traversed by the horse and vehicle. But in America we think infinitely more of our own comfort than of that of the patient horse, and here and there along the country road an occasional attempt is made to construct a side walk. No elaborate directions need here be given. A well laid walk three or four feet wide will accommodate most of the foot travel along our country roads and if this is made of clean gravel or finely broken stone, laid out with regular and parallel sides, it will serve well its purpose. For a four foot walk, there should be a crown of three inches at the centre of the newly made walk, to insure good drainage and to make allowance for settling. The appearance of the walk is improved by a strip of sod on each side and the cross section of the path should be so formed that drainage will be carried to the surface of the grass on both sides. The line between the walk and grass on each side can be preserved by setting in the ground on each line a row of field stone or cobble stones, allowing them to project about two inches above the ground. Where a side walk is laid on only one side of the road, it should be laid on that side which will offer the best advantages in point of drainage and the avoidance of obstructions.

A plank walk may be made by simply grading the earth in the line of the walk and laying three 4x4 inch stringers about fifteen inches apart (centre to centre) and spiking strips of two inch plank cut to a uniform length of four feet, with thirty penny nails. The planks should be set three-eighths of an inch apart. In wet and springy soils drainage should be provided for in the same manner as drainage of the roadway, although in cases where the roadway and side walk are about on the same level, a single line of drain tile properly located will be found to be sufficient to thoroughly drain both.

Shade Trees.—If the earth of the roadway is heavy and difficult to drain, shade trees should not be planted too closely together, and they should be trimmed of all heavy foliage to a considerable height from the ground so as to let in the sun and air and thus hasten the drying of the road after a storm. If the ground is well drained, nothing will add more to the beauty of the road or to the pleasure of the traveler, than a line of sturdy trees on either side of the road. Elms, rock maples, horse chestnuts, oaks, beeches and pines are among the favorites in different parts of the country. The soil and climate will determine what tree can be set out to the best advantage and the judgment of the reader will guide him as to what distance apart the trees should be planted. Thirty feet for elms and a shorter distance for less spreading varieties will serve as an approximate rule. Trees should not be planted too near a line of under drains as the drain is likely to become clogged by the fibrous roots.

In Brief.—On earth roads the road machine should be frequently and thoroughly used. It is best used when the soil is damp but not muddy.

Keep the surface ditches open; divide the work in each town or road district and make each man responsible for the care of the road within fixed limits.

Keep the roadway dry and use wide tires to roll it and insure its smoothness. Front wheels and rear wheels should not "track;" make the rear axles longer than the front; tracking wheels produce deep ruts; you never saw ruts at a turn in the road.

Give to the road machinery of the town the same care and attention that you would give to your own.

If you find your work to be successful and your roads improved, write to the Publisher and state your experience and your opinion of the value of a good road. Name and address on the front cover.

IV.

CROSS DRAINS AND CULVERTS.

CROSS DRAINS SHOULD BE SOLID AND PERMANENT—WOODEN CROSS DRAINS; HOW TO CONSTRUCT THEM—PIPE CULVERTS; THEIR ADVANTAGES, AND HOW TO LAY THEM—PRICE LISTS OF CAST IRON AND VITRIFIED PIPE—STONE CULVERTS—AMPLE WATERWAY TO BE PROVIDED; HINTS AND SUGGESTIONS FOR PLANNING DRAINS AND CULVERTS—VOLUME OF RAINFALL—CAPACITY OF PIPES.

HERE and there along nearly every country road we find a place where the roadway is crossed by a small stream, and where the stream is not so large as to demand the construction of a bridge or a culvert, a small cross drain may be used as a channel to conduct the water across the road; but this drain should be substantially made, so as to be solid and permanent, for the caving in or washing out of a badly built drain has broken the leg of many a good horse, and brought disaster to many a traveler who has staked his faith on the fidelity of a shiftless and incompetent path master and gone abroad at night on the country highway.

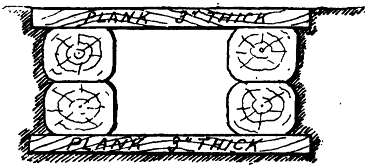


FIGURE 31.
Wooden Cross Drain.

Wooden Cross Drains.—Wood is perishable and is not well adapted to the making of drains, but it is cheap and, in many localities, is the only available material from which a drain can be made at a reasonable cost. If stone cannot be had and drain pipe is out of the question, a substantial cross drain can be made of flattened timbers and planks, as shown in Fig. 31. In making this drain the trench is dug across the road in the line of the drain and of sufficient depth and width to contain the timber and planks. Then the bottom is carefully formed so as to make a smooth, solid foundation, having a slight grade or pitch in the direction in which the water is to run. Two flattened timbers are then laid at some convenient point on the roadway near the drain and so placed as to be parallel with each other and as far apart in the clear as they are designed to be when placed in the drain. A course of three-inch plank is then spiked across these timbers from end to end, using 50-penny nails for this work, until the course of planks extends from end to end of the timbers. This row of plank is to be the bottom of the drain and when the short bottom planks are securely spiked to the timbers, the timbers are turned over (thus bringing the planks at the bottom) and placed

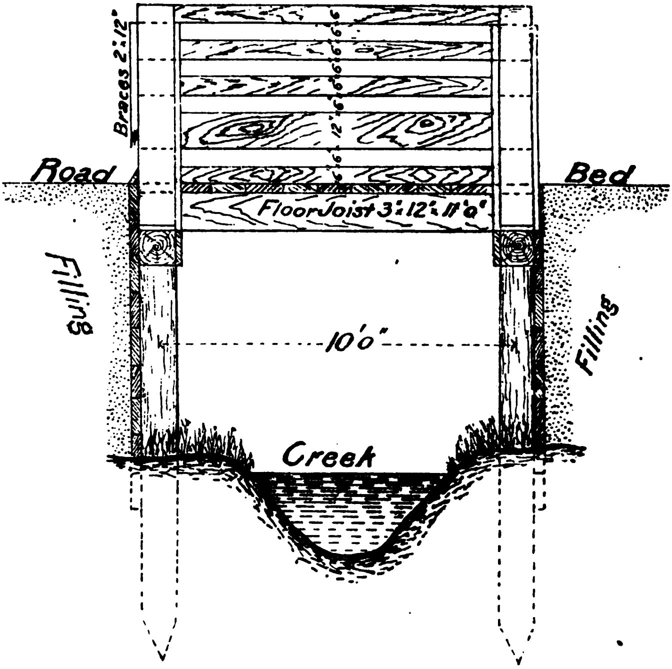


FIGURE 32.

Side view of timber short span, crossing over creek or open drain ditch. Dimensions are given in the figure. This makes a very substantial structure when new, and in many parts of the country can be put up cheaply and will prove a great improvement over the structures now used for a similar purpose.

in the pit dug to receive them. After this is done another pair of flattened timbers are placed on the top of the first course already in place, and three-quarter inch auger holes bored through the centre of the top timber and half way through the *bottom one,* about four feet apart throughout their entire length.

Into these auger holes should be driven, securely, drift bolts, three-quarters of an inch square, and of sufficient length to fill the auger holes, and the timbers are thus securely fastened together. In the same way, if necessary, another course of timber is put on top of the ones already in place, till the drain walls reach the height of the surface of the road, after which another course of three-inch plank is securely spiked crosswise over the top of the drain, and, over this, for greater strength and permanence, it may be well to spike a layer of three inch plank endwise across the roadway or at right angles with the shorter planks which are spiked directly to the timbers.

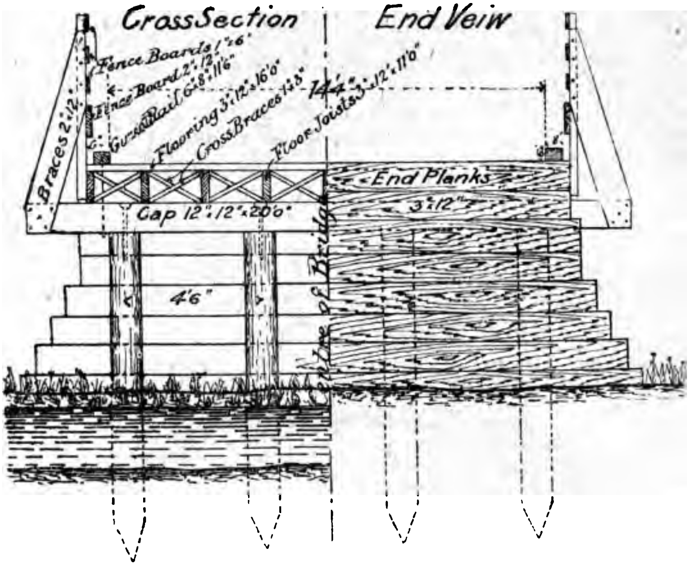


FIGURE 33.

Cross section and end view of drain crossing shown in Fig 32. The dimensions of the different parts are shown in the figure.

Figures 32, 33 and 34 show plans for a short span crossing where the opening is too large for the ordinary cross drain. It is adapted to locations where the ground is soft and the flow of water sluggish, but like all timber structures can only be depended upon to last for a few years.

Other forms of wooden culvert will suggest themselves to the ingenious mechanic, and no single plan can be suggested which may not be more or less modified to advantage to meet the conditions presented in different localities.

Pipe Culverts.—A good pipe cross drain or culvert, if well laid, will last for many years and will supply a regular and sufficient waterway, and one that is easily cleaned; and if the top of the pipe is set a foot or more below the surface of the road, so *as not to be injured* by contact with the wagon wheels and horses'

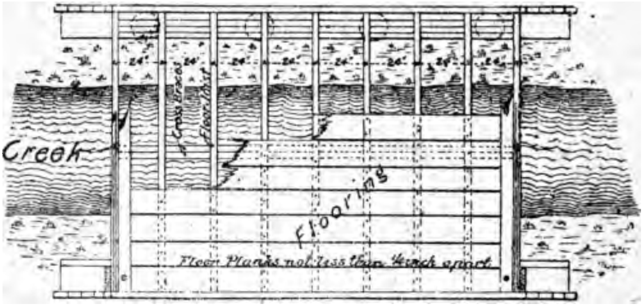


FIGURE 34.
Top view or plan of drain or small creek crossing shown in Figs. 32 and 33, with dimensions of parts.

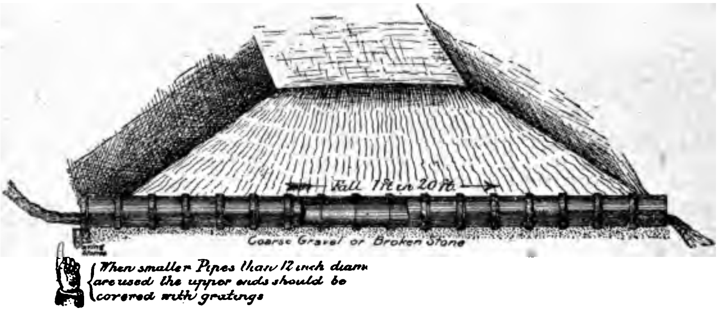

Fall 1 ft in 20 ft
Coarse Gravel or Broken Stone
When smaller Pipes than 12 inch diam
are used the upper ends should be
covered with gratings

FIGURE 35.
Cross section of roadway embankment showing vitrified pipe culvert. The pipe is well fitted, carefully bedded in a bed of course gravel or broken stone, the joints cemented or filled with stiff clay and carefully covered. In many places the abutments at the ends may be omitted, but to protect the pipe and the bank it is best to terminate each end of the drain in a good wall or block of rubble masonry, or brick.

feet that pass over it, such a drain is probably the best that can be used on a common dirt road. Cement pipe may sometimes be used to advantage, if made by a reliable manufacturer; but vitrified stone pipe is generally more reliable and more durable. Only the "Salt glazed" pipe should be used.

When pipe is used for a cross drain or culvert, a substantial face wall or abutment should generally be built at each end to contain and protect the ends of the pipe. The bottom of the abutment should be located far enough below the bottom of the pipe to escape the effects of frost which might heave and disrupt it.

These face walls or abutments may be made of brick or of common rubble masonry in which the stone should be laid in strong cement mortar and well bonded.

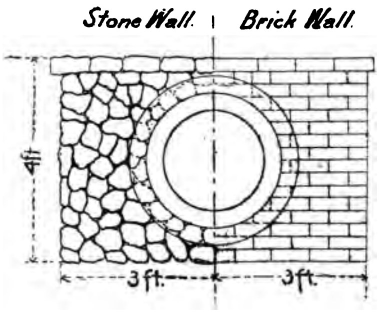


FIGURE 36.

End view of abutment wall for vitrified clay or iron pipe culvert. One-half the figure is shown in rough stone and one-half in brick. Either may be used.

Iron Pipe Culverts.—For durability, cheapness of laying and thorough reliability, no form of culvert surpasses those made of iron pipes. They are largely used by many of our railroads, East and West, in the laying of small culverts and by hundreds of highway officers in all parts of the country. It is made in twelve foot lengths and the pipe is thick enough to sustain the heaviest loads which pass over it—the thickness increasing with the size of the pipe. Two or three lengths will generally be sufficient for a roadway crossing. Where the bank is low and the flow of water large, two or more lines of pipe can be laid side by side to provide for complete drainage. Cast iron pipe of different sizes will cost about as shown in table on following page, reckoning the price at $35 per ton.

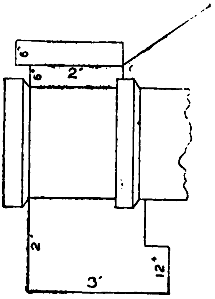


FIGURE 37.

Showing form and dimensions of abutment for pipe culvert; inlet or up stream end.

In laying iron pipe culverts the lengths should be carefully joined and bedded and the ends set in brick or stone masonry. When the pipe is smaller than twelve inches in diameter, a screen or grating should be put in at the up-stream end to keep out flood trash and prevent the choking of the drain.

COST OF CAST IRON CULVERT PIPE.

8 in.	pipe,	12 feet long,	weight	·480 lbs	$ 8 40
10	"	"	"	600 "	10 50
12	"	"	"	840 "	14 70
14	"	"	"	1200 "	21 00
16	"	"	"	1320 "	23 10
18	"	"	"	1500 "	26 25
20	"	"	"	1800 "	31 50
24	"	"	"	2160 "	37 80
30	"	"	"	3060 "	53 55
36	"	"	"	3900 "	68 25
48	"	"	"	7200 "	126 00
60	"	"	"	12000 "	210 00

If our roadway is provided with a centre drain, or if an under drain has been placed at either side of the road, we had better put branch pipes in the line of our culvert to receive the water from the under drain in the roadway.

The following brief table of manufacturers' list prices of vitrified culvert pipe is inserted for the benefit of the reader, but he must bear in mind that in purchasing he will find the dealers ready to quote a very large discount from these prices, as in the case of drain tile already mentioned:

PRICE LIST OF STANDARD VITRIFIED CULVERT PIPE.

	Per Foot.	Bends.	Branches, 2 ft.	Traps.
2 inch	$0 14	$0 40	$0 63	$1 00
3 inch	16	50	72	1 50
4 inch	20	65	90	2 00
5 inch	25	85	1 13	2 50
6 inch	30	1 10	1 35	3.50
8 inch	45	1 80	2 03	5 50
9 inch	55	2 25	2 48	6 50
10 inch	65	2 75	2 93	7 50
12 inch	85	3 50	3 83	10 00
15 inch	1 25	4 75	5 63	15 00
18 inch	1 70	6 50	7 65	
20 inch	2 25	7 50	10 13	
24 inch	3 25	11 00	14 63	
30 inch	5 50	20 00	24 75	

Slants.—Fifty per cent. more than plain pipe, measured on long side, but not less than 12 inches.

Increasers and Reducers.—Double price of two feet of pipe size of larger end.

Stoppers.—One-third of one foot of pipe of the size on which it is used.

The carrying capacity of each of the different sizes of culvert pipe will *correspond with* the figures showing the capacity of drain tile, printed on *a preceding page.*

Each length of drain pipe has a "socket" end into which the plain end of another length is made to fit. In laying the pipe drain the bottom of the trench in which it is laid should be made solid, and should have a form and grade corresponding to the form and grade of the pipe which it is to contain, and little "hollows" should be scooped out across the bottom of the trench into which the sockets or collars of the pipe will fit, so as to permit the body of the pipe to rest on a firm bearing at the bottom and sides of the trench. If the ground is sandy, or of so loose a nature that these depressions or hollows cannot be scooped out, it will be necessary to lay the pipe to grade throughout the length of the drain ditch and then ram the loose sand or earth beneath and around the lower half of each pipe, so as to give it a firm bearing.

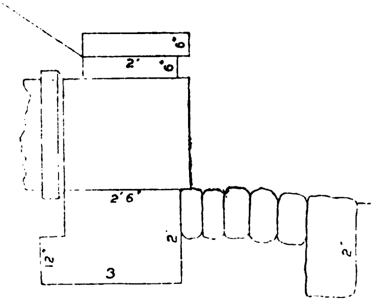


FIGURE 38.

Showing form and dimensions of abutment for pipe culvert; outlet or down stream end.

The joints of the pipes are sometimes cemented, but there is some difference of opinion on this point, and in most cases it will answer quite as well to cover them securely with stiff clay well packed around the joints.

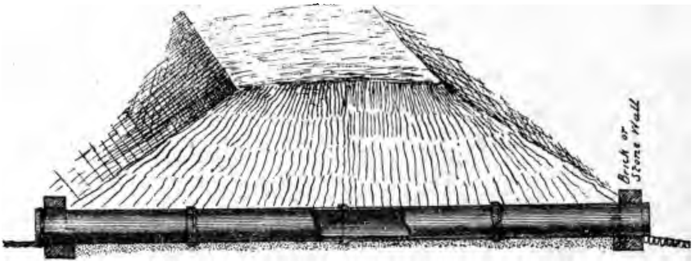


FIGURE 39.

Cross section of roadway embankment with iron pipe culvert. The pipes should be well "bedded" in firm material at the bottom, carefully fitted at joints and the joints calked and "leaded" or packed with stiff clay before the pipe line is covered.

Stone Culverts.—In some localities good stone is plentiful and cheap, and this fact, with perhaps other local considerations, will sometimes make it seem best to reject the use of pipe and to construct a stone culvert. In nearly every case rough rubble masonry will answer every purpose.

The following brief suggestions will aid the reader in the general work of planning and overseeing the construction of a stone culvert. As already stated, rough rubble masonry will answer every purpose in making the culvert for an ordinary dirt road, but in laying the stone-work plenty of "headers" should be used, so as to give the stone a strong bond, and heavy stones should be used at the angles of the up-stream end of the culvert to resist the action of flood trash and floating ice in the season of heavy freshets. The opening or water-way of the culvert should be ample to admit of the passage of large bodies of water; the bottom of the opening should be paved with stones set on edge and given a downward curve in the centre, something after the style of an inverted arch.

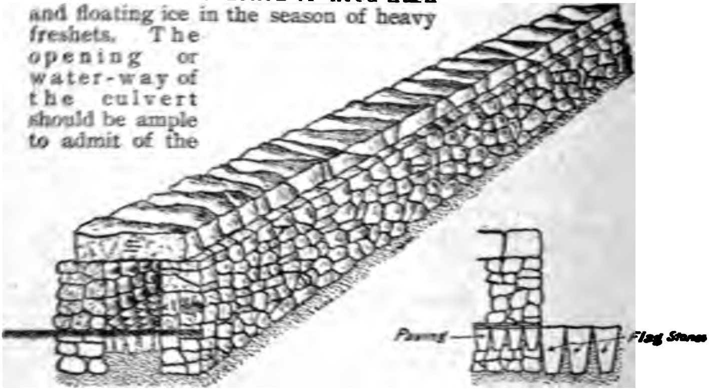


FIGURE 40.

View and section of rough rubble stone culvert. Walls eighteen inches thick; cover one foot thick; paved at bottom and outlet to prevent washing out. The stone is laid in hydraulic cement mortar and the work can be done for a price varying from $[illegible].50 to $[illegible] per cubic yard.

Section of Ends showing Paving & Flag Stones

The cover or top stone of the culvert should be at least several inches below the surface of the roadway and the bottom of the culvert foundation should be below the frost line.

On this subject of drains and culverts it may be well for the reader to know something of the question of rainfall. Each culvert or drain will naturally be required to pass an amount of water which comes from the adjacent "water shed" (or land from which the water will flow toward and through the culvert). *One inch* of rainfall per hour indicates a heavy downpour.

This amount gives in round numbers 23,000 gallons of water per acre per hour, or about 377 gallons per minute per acre. Much of this water will, of course, be held back by various obstacles, and not more than 70 per cent. will reach the culvert in the hour in which it falls. If a certain water-shed is composed of a thousand acres, then the heaviest rain storm will pour out upon this water-shed about 377,000 gallons per minute, and if the water-shed is made up of steep side hills and rocky slopes, the water will run off quickly and reach the culvert soon after it falls, while, on the contrary, if the water-shed is composed of flat lands, gentle slopes and porous soils, the water will reach the culvert more gradually and much of it will be absorbed in the earth.

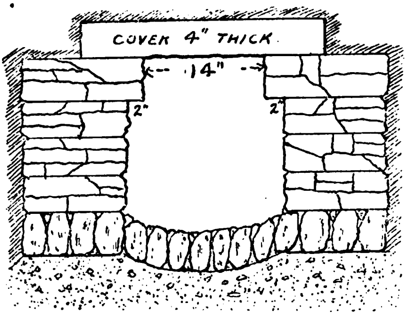


Figure 41.
Showing cross section of ordinary stone culvert.

If drain pipes should be used it is well to remember that where the road surface is only a short distance above the culvert stream, and the road maker is thus prevented from using as large a pipe as he would otherwise select, he may avoid the difficulty by using two or more lines of pipe, laid side by side across the roadway, building them into the abutment at each end, as already described in the case of a single pipe.

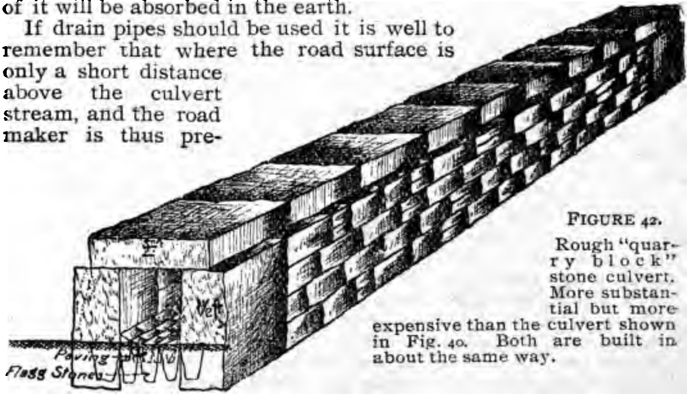


Figure 42.
Rough "quarry block" stone culvert. More substantial but more expensive than the culvert shown in Fig. 40. Both are built in about the same way.

V.

BRIDGES.*

IRON BRIDGES RECOMMENDED; THEIR GROWING POPULARITY; BRIDGE COMPANIES WELL EQUIPPED TO SUPPLY THE BEST WORK—PRACTICAL HINTS AND SUGGESTIONS — ALLOWABLE STRAIN — WOODEN BRIDGES SOMETIMES NECESSARY—FOUNDATIONS—TIMBER FOR BRIDGES AND SEASONING—SIMPLE FORMS —DIMENSIONS OF STRINGERS — PLANS FOR WOODEN BRIDGES OF DIFFERENT LENGTHS; DIRECTIONS FOR BUILDING.

WROUGHT iron and steel are rapidly displacing wood in the construction of all important bridges, and even for short span bridges on country roads these metals are now largely employed because of their greater strength and durability, better appearance and the sound economy shown by every public officer who erects a safe and permanent structure in place of a doubtful and temporary one.

The making of iron and steel bridges is a specialty, and several of the large bridge companies have brought the art to a point of perfection which ordinary engineers can scarcely hope to surpass. These companies employ the best experts both in designs and manufacture and put their work together with so much facility and at so reasonable a price as to leave little excuse for the erection of a wooden bridge. The writer will only suggest one or two points regarding the selection of an iron bridge:

Deal with a responsible company—a concern capable of filling its obligations and keeping its contracts—a company of reputation that is known to use good materials and to supply all parts of full dimensions and weight without "skinning" and weakening its work. If the stream or gorge to be spanned is of considerable width, let your engineer determine by a careful survey the number and length of spans to be put up. Iron piers are cheaper than masonry and in many cases these can be supplied by the bridge companies at a great saving to your town. The width of roadway should be somewhat in proportion to the length of span.

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*A separate number of POTTER'S GOOD ROADS LIBRARY devoted entirely to the subject of "Highway Bridges" and fully illustrated, is now in course of preparation by an able and experienced bridge engineer and will appear in the Fall of the present year, 1894.

It should generally be not less than fourteen feet and may be eighteen or twenty feet when space is required for the passage of two wagons. Calculation should be made for a live load in pounds for each square foot of roadway and the strength of the bridge should be fixed accordingly. For common country bridges not on main roads, this load may be reckoned at 100 pounds per square foot; for bridges in towns and on principal country roads, this estimate may run fron 110 to 125 pounds for width of roadway not exceeding eighteen feet. These figures are for spans of sixty feet and under. For longer spans the live weight per square foot is a trifle less.

Allowable Strains.—Wrought iron should not be subjected to a strain of more than 12,500 pounds per square inch for principal tension rods nor more than 10,000 pounds for counters and suspension rods; floor beam hangers, 9,000 pounds per square inch; compression members, 10,000 pounds per square inch. Good bridge iron will stand from 45,000 to 50,000 pounds per square inch; 24,000 to 26,000 pounds elastic limit; will have a good fibre and can be bent cold from ninety to 180 degrees without fracture.

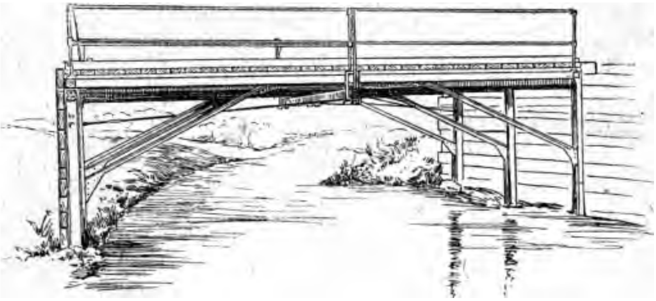


FIGURE 43. THIRTY FEET SPAN I-BEAM CANTILEVER BRIDGE.

Built by the Indiana Bridge Company. This bridge is one of several hundred of similar style built on lines of country roads. Simple cantilever bridges can be used for spans up to seventy feet. They are strong, durable, neat and can be put up at a very reasonable price.

In writing to a bridge company for estimates, state the number and length of spans required, the width of roadway, whether sidewalks are required or not and if so, whether upon one side or both; capacity; kind of substructure; height of bottom of bridge from bed of stream; kind of lumber required (for flooring and timbers) and what it will cost per thousand delivered at the proposed bridge site; distance to the nearest railway station. This information will enable the company to supply a more accurate *estimate and* perhaps give you a lower bid.

Place your contract for an iron bridge in the early Fall, so th the shop work may be done in the Winter and the bridge put in place early in the Spring. This will result in placing your work in the shop when work is generally slack and will enable you to get lower estimate and prices.

Wood is only about one-fifteenth as strong as iron, and besides being very perishable and hence only suitable for temporary structures, it loses much of its strength by the cutting and fitting of the various parts whenever it is used for the making of a highway bridge. The bridge is the weakest point in every highway and it should be made as strong and reliable as possible. The writer has seen many substantial and lasting wooden bridges, but the best wooden bridge cannot be fairly compared with a well made steel or iron structure, either in point of strength or durability. In some parts of the country wood is still used for bridge making because it is closely at hand and the question of first cost is so important as to prevent the purchase of an iron bridge. Having in mind this fact the writer will include here a few hints and time-proved plans for the making of substantial wooden bridges; still urging his readers the better economy and wiser policy of putting up an iron bridge whenever the money is available or the public credit good enough to meet the expense.

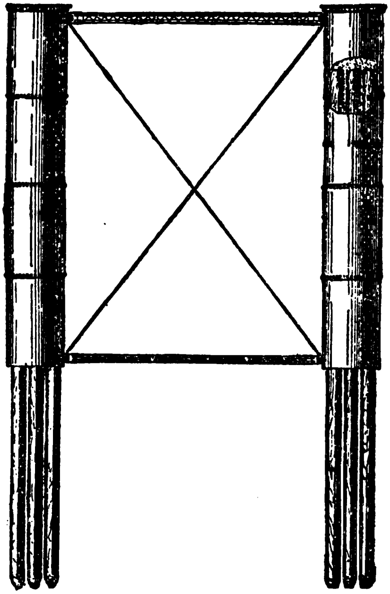


FIGURE 44. IRON SUB-STRUCTURE (PIER OR ABUTMENT).

The piles are driven well into the ground so as to insure a firm "footing" and the space inside the cylinders is filled with concrete which, when packed about the piles, becomes a solid stone mass and makes a very firm foundation. In all locations where heavy masonry piers and abutments are not positively required, this form provides an excellent substitute at much less cost.

Foundations.—By all means leave this subject to the skill and *judgment of a* good civil engineer in your locality. If the bridge *is of short span* and the earth at the bridge site uniformly firm, an intelligent stone mason or contractor may complete a very excellent job, but unless the work is done by day labor, a good engineer or inspector had better be employed to oversee the work. Abutments for country road bridges of short span are generally made of rubble stone masonry, laid in hydraulic cement mortar, mixed in the proportion of two parts sharp, clean sand to one part American Rosendale cement or any other good cement of equal strength. The face of the abutment generally has a batter of about one inch to the foot and the thickness of the abutment at the bottom is about two-fifths of the height. Where the pressure from the earth filling in the rear is slight, stone work may be saved by "stepping off" the abutment on the back.

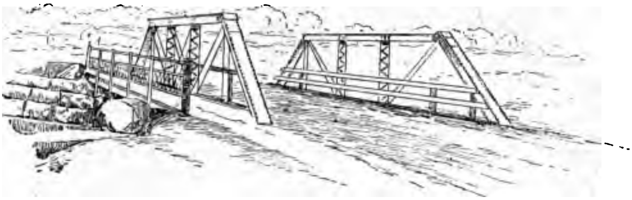


FIGURE 45. IRON BRIDGE, SIXTY FEET SPAN, "PONY TRUSS," AT CIRCLEVILLE, OHIO.

The roadway is eighteen feet wide, the sidewalk six feet. A very excellent form of highway bridge for country roads and village streets. Trusses of same general dimensions and style are supplied by bridge companies in different parts of the country.

Timber for Bridges.—Trees should be cut after they have reached full growth and before they begin to decay. The sapwood which is always nearest to the bark decays quickly and is unfit for permanent work. The heart of the tree is dark in color, firmer, stronger and more durable. Trees are generally cut in the winter months and in July when the sap is not in circulation, though recent writers declare in favor of cutting trees in Mid-summer and Autumn, claiming that experience shows these to be the most favorable seasons.

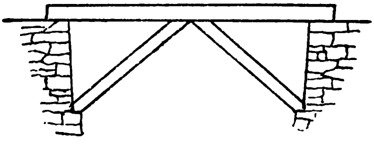


FIGURE 46. SHORT SPAN BRIDGE STRINGER WITH BOTTOM STRUTS OR BRACES. MAY BE USED FOR SPANS UP TO THIRTY FEET.

Timber should be well seasoned before being used for bridge *work. To be thoroughly* seasoned by natural means about two *years are required.* The timber should be sawed or cut in prop lengths and sizes, and sheltered from the direct action of wind, rain and snow, but exposed to the free circulation of air. If laid in piles narrow strips should be placed between the separate timbers, to admit air on all sides.

Pins for Connections.—In the making of wooden bridges and especially wooden lattice bridges, hard wood pins have been commonly used to connect the pieces together. These pins are extremely weak in proportion to the surface they present unless they are made so large as to require an undue cutting of the timber. Iron pins and bolts are much better and stronger, insure a neater job and their use avoids an undue mortising or boring of the timbers and plank.

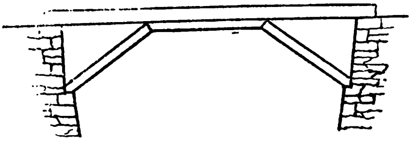


FIGURE 47. ANOTHER FORM, SHOWING APPLICATION OF STRUTS OR BRACES FROM THE BOTTOM.

The simplest form of a highway bridge is that composed of beams or stringers laid across from one abutment to the other and supporting the floor. For a width of bridge not exceeding sixteen feet the following dimensions may be used:

Span in Feet.	Number of Beams or Stringers Used.	Size of each Beam or Stringer.
5 to 7	2 3 4	8 x 10 6 x 10 4 x 10
8 to 10	2 3 4	9 x 12 8 x 12 6 x 12
11 to 13	2 3 4	10 x 14 8 x 14 6 x 14
14 to 16	2 3 4	12 x 18 9 x 18 6 x 18

Iron I-Beams.—Even where simple beams are used it is better to employ iron I-beams if possible, as they last for an indefinite time and are subject to none of the defects which are so frequently the cause of failure in wooden bridges. The price *for iron* beams in small quantities ranges from three to five cents *per pound according* to locality. There are special discounts on *large orders.* A couple of fifteen inch iron I-beams weighing

200 pounds per yard, will carry all the wagon traffic on an ordinary road where the width of roadway is not more than fourteen to sixteen feet and the span between abutments not over twelve feet.

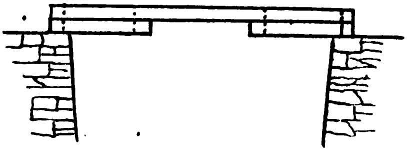


FIGURE 48. STRINGER STIFFENED BY CORBELS.

Where the span exceeds sixteen feet or where timbers of sufficient strength cannot be had for the opening spanned, smaller stringers may be used and these may be braced from the bottom by struts set against shoulders formed in the

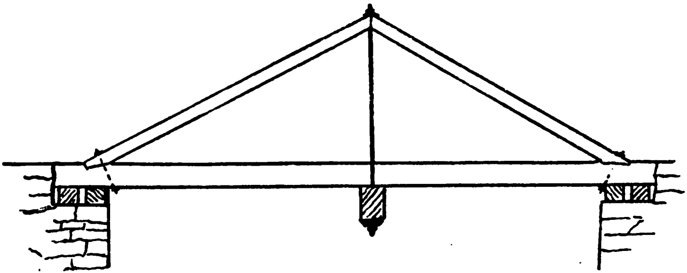


FIGURE 49. SIDE ELEVATION OF TRUSS FOR TWENTY-FOOT SPAN WOODEN BRIDGE.

The bottom chord or stringers in each truss is 6 x 8; each rafter main brace is 5 x 6. The needle beam or transverse beam is 6 x 8. Two one-inch rods run from the peak of each truss downward and support the transverse or needle beam. The two suspension rods in each truss diverge to a wider opening at the bottom, through which the lower chord passes. This arrangement avoids boring the lower chord at the centre and increases the stability of the truss. The toe of each main brace or rafter is fitted into the lower chord by two shoulders cut to a depth of 1½ inches at the outer extremity and ¾ of an inch at the inner extremity of the cut. This cutting of the shoulder should be at least 20 inches from the end of the chord. Two ¾ inch bolts secure the lower ends of each brace with washers under the heads and nuts. The suspension rods at the centre are provided with ample iron plates and washers at top and bottom, the plates being half an inch thick and fitted to the surface of the wood with which it comes in contact. Under the ends of each truss, for greater security, may be spiked (along the lower side of each chord) a strip of hard wood plank 2 x 6 and about 2½ feet long. For a roadway 14 feet wide between trusses, 6 floor timbers 3 x 8 in size, should be laid lengthwise with the bridge resting on the abutments and transverse beam. Two of these should be placed against the inner sides of the two trusses and the other four set at equal distances apart across the roadway. For the flooring 2-inch plank may be used. Height of truss is equal to one-third its length.

abutment and meeting at the centre of the stringers, as shown in Fig. 46. By this simple arrangement spans of from twenty-five to thirty feet may be made secure. The same principle is followed in Fig. 47 in which a straining piece is bolted to the centre of the stringer and between the ends of the two struts. Sometimes it is necessary to have the space beneath the bridge entirely clear, and in such cases bracing from the bottom must be omitted, and another means found for strengthening the stringer. This is sometimes done in a simple manner by bolting substantial timber corbels to the bottom of the stringer *from each* end to a distance of several feet toward the centre *as shown in* Fig. 48, but this arrangement is unsightly and *is rarely* adopted, though corbels of smaller size are com*monly* used on the bottom chord of wooden trusses. Perhap

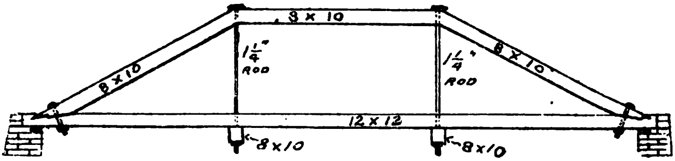


FIGURE 50. PLAN FOR A THIRTY-FOOT-SPAN BRIDGE.

The dimensions of pieces composing the truss are shown in the plan. The wall plates may be either 8 x 12 or 10 x 12. Each panel is one-third the length of the bridge. Each brace is fitted at the toe by a beveled cut in the bottom chord as described in Fig. 49. In forming this truss as well as that in Fig. 52 a slight "camber" should be given the truss by properly fitting the timbers and screwing up the suspension rods. This truss will contain about three thousand feet, board measure, of timber and about two hundred and fifty pounds of iron.

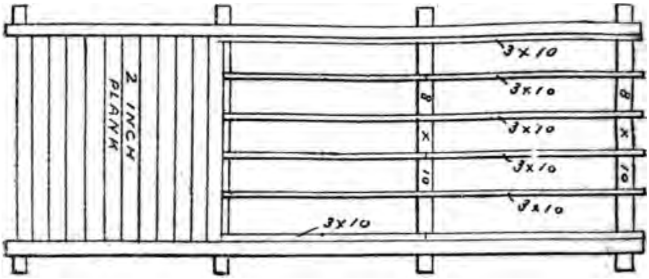


FIGURE 51.

Showing arrangement and dimensions of floor timbers and planking of bridge shown in Fig. 50. The same arrangement is equally good for the larger span shown in Fig 51.

the most common form of country bridge is that shown in Fig. 49 which is easily applicable to spans ranging from sixteen to twenty-five feet. The dimensions given under the figure are about right for a twenty-foot span.

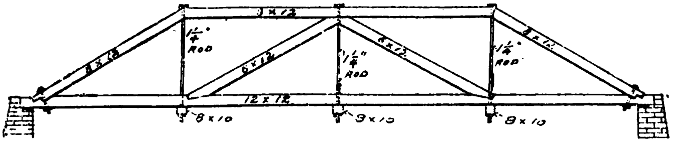


FIGURE 52. PLAN OF FORTY-FOOT BRIDGE.

The dimensions of principal parts are show in the plan. The arrangement and dimensions of floor and floor timbers are the same as in Fig. 50, and the method of construction is the same as in Fig. 50. When the span is so great as to require a considerable height of truss, the tendency of the truss to lean may be diminished and its stability increased by using two suspension rods at the end of each needle beam; causing these to diverge as they proceed downward from the truss and passing the lower chord between them.

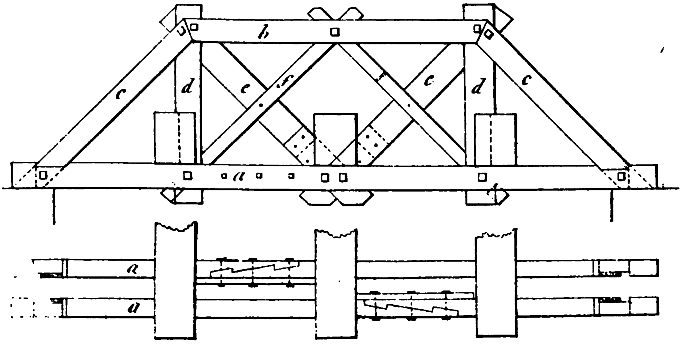


FIGURE 53. PLAN FOR A FORTY-FOOT-SPAN BRIDGE.

Scale for lengths of timbers, 1 to 100; other dimensions, 1 to 30. The design shown in this figure was originated many years ago by Mr. S. Whipple, a civil engineer and bridge expert, and adopted with much success for many wooden structures throughout the country. The description is taken from the language of the original designer.

In this truss, the upper and lower horizontal stringers *a* and *b*, are each composed of two pieces, 6 inches deep by 4 inches thick, and placed 6 inches apart.

The brace *c* is 6x14, edgewise to view, with 6 inches cut out of the middle, *at the upper end*, to make room for *d* and *e*. At the lower end, it is fitted *into a boxing of 1* inch depth, upon the upper and inner sides of the *stringers a*, while the middle portion, 6 inches in thickness, runs down to the abutment, being beveled off even with the lower side of *a*. The vertical, *d*, consists of 2 planks, 8x2½, placed 3 inches apart, to receive the upper end of *e*, and a 3 inch tenon formed on the lower end of *f*, between. There is a boxing 1 inch deep at each end to let in the upper and lower stringer pieces, and the vertical pieces should extend at least 6 inches beyond the boxing. There is also a boxing in *d*, just above the stringer *a*, an inch deep, in the edge, to receive the cross bearer, and the cross bearer is boxed 4 or 5 inches deep, to receive the verticals *d*.

The diagonals *f*, *f*, 3½x7 inches, are locked or tenoned together at the upper end, and fitted into a half inch boxing on the inside of the upper stringer *b*. In the centre is a mortise 3x7 inches for the piece *e* to pass through. The lower end is reduced to 3 inches wide between the pieces *d*, and 4 inches at the end, having a head, or reversed shoulder fitting a triangular boxing inside of *d*, shown by dotted lines.

The diagonals *e*, *e*, are secured each by 2 bolts of 1½ inches diameter, and a few spikes at the upper end; and at the lower end they are halved and locked together, with a piece of 2 inch plank, 2½ feet long, locked, bolted, and spiked on to each, and extending across the other to the end. These short pieces, being reduced to 1½ inches thick, except for 6 inches at the upper end, which forms the locking, they just fill the 6 inch space between the stringer pieces. Two bolts of 1¼ inch iron, through stringer and diagonals, with a few spike, complete the arrangement at this point.

To secure the vertical position of the truss, a brace and tie runs up from a point in each cross beam, about 2½ feet from the centre of the truss, to or near the top stringer, being secured at each end so as to act by either tension or thrust, with a force of some 2000 lbs. each. Perhaps the best arrangement for this purpose is, to use a 3 inch square, or 3x4 scantling for the brace, with a ⅝ iron rod running beside it for the tension. These are not shown in the figure.

If the lower stringers cannot be obtained of the whole length, they may be spliced by a two-lock splice between cross beams, with a piece of 2 inch plank about 6 feet long, which will extend 16 inches beyond the lap each way, well spiked on to the inside. Six inch pressed spike (½ inch iron), the points drawn about an inch for clinching, with a portion of 5 inch spike, may be used to advantage in this splice.

But the splicing, at best, adds considerably to the expense, and it is better, when practicable, to obtain stringers of the full length, even at a considerable extra cost per foot.

The writer might multiply hints and designs for wooden bridges to an indefinite length, but it is the intent of this little book to give only such practical information on the subject of bridges as will lead the reader in the right direction and enable him to avoid disaster which so often occurs as a result of shiftless and ignorant work.

Bridge building requires special knowledge and every tyro cannot afford to undertake it. For every important structure employ the best skill available and put up the best and most substantial bridge that your money can afford; always a stone or iron bridge when such a thing is possible.

THE END.

MACADAM ROADS.

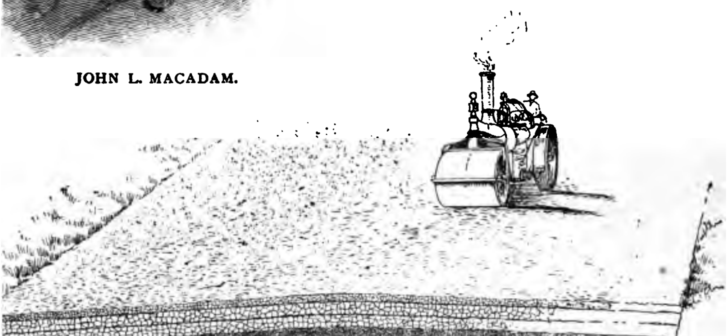
(No. 2 of POTTER'S GOOD ROADS LIBRARY, ready August first, 1894.)

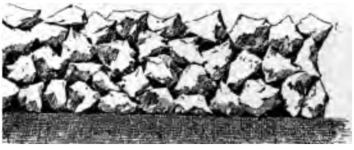
JOHN L. MACADAM.

A complete and **FULLY ILLUSTRATED** practical hand book on the making of Macadam roads. It contains the **meat and pith of the best information** gathered from the experience of European and American road makers.

It tells what a Macadam road is; describes old and new methods; shows that Macadam roads are easy to make and easy to maintain; gives **SIMPLE RULES FOR CONSTRUCTION** and **ESTIMATES OF COST;** tells why rolling is necessary and how rolling should be done. It treats of **grades** and **drainage,** describes the different kinds of stone, tells what stone is suitable and what is not, refers to trap, lime- e, flints, **FIELD STONE,** river stone and other varieties; tells how to hem. It gives you the **COST OF STONE BREAKERS** of different makes; tells what they will do; what power is necessary; the **cost of steam power** and **steam engines,** with suggestions for care and **use of machinery.**

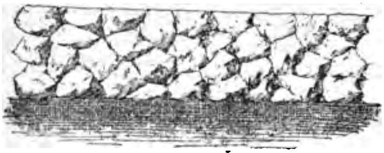
It tells you how to **spread the stone;** what size to use; describe the best methods of rolling, filli





LOOSE, OPEN AND ROUGH.

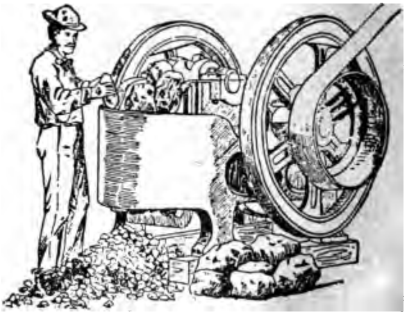
MACADAM ROADS.



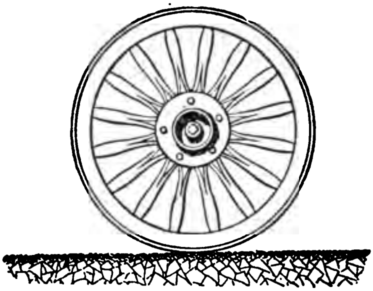
SOLID, TIGHT AND SMOOTH.

and sprinkling, and gives suggestions for **REPAIRS** and maintenance, with hints for **keeping a Macadam road in good** condition at the **lowest cost.**

It takes up a subject not **heretofore** referred to in works on Macadam roads but specially important in this country: to wit, the **USE OF WATER POWER** in the making of road metal (broken stone) for road work. **In** hundreds of localities in this country splendid water power is running to waste in streams that are lined on both sides with rocks and stones that would make the best road material.



This little book tells **HOW TO MEASURE A STREAM;** how to determine the power it will supply; **how to build a dam** and what a water wheel will cost and what it will do.



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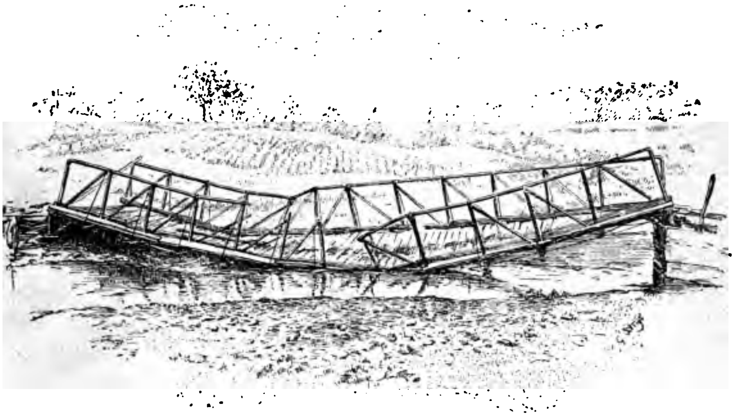

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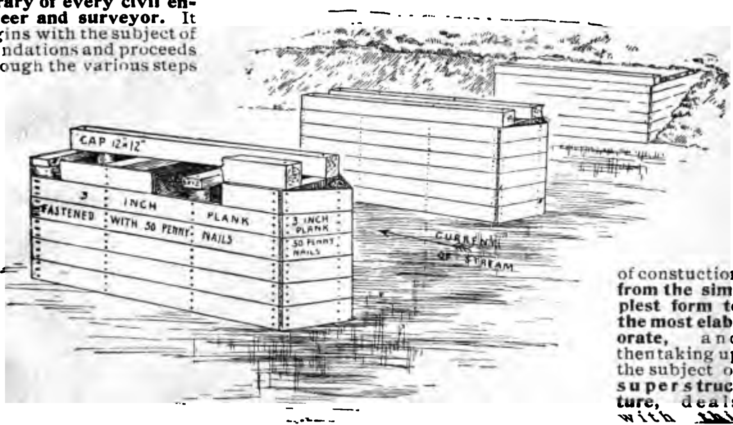

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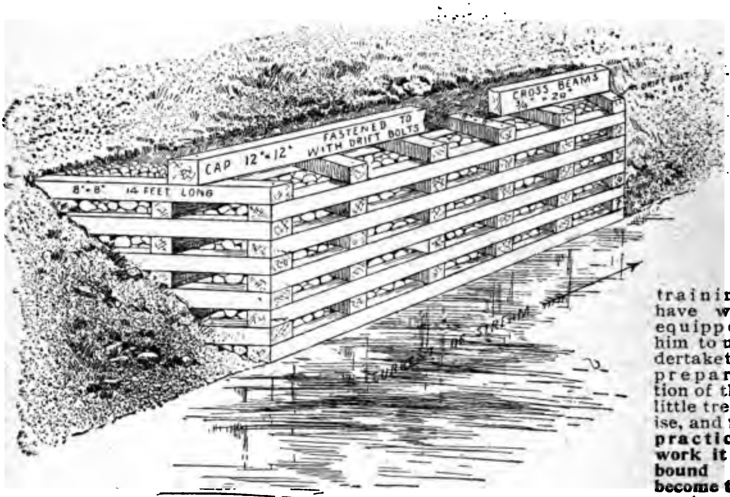

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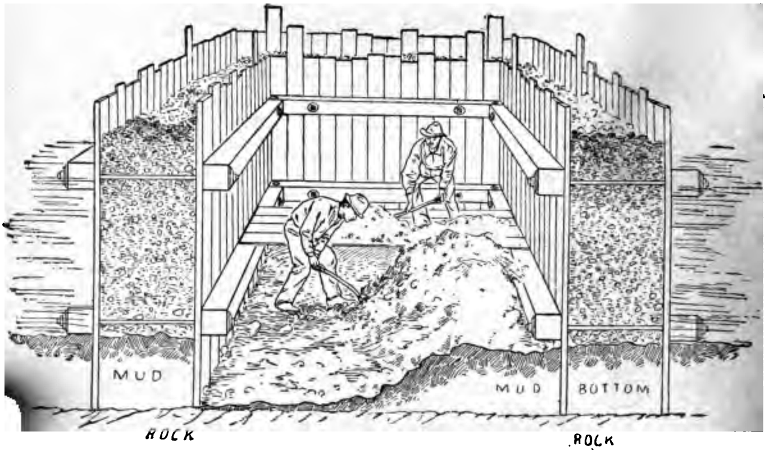

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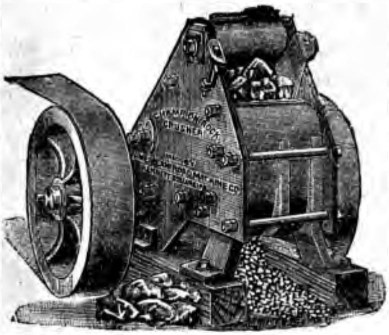

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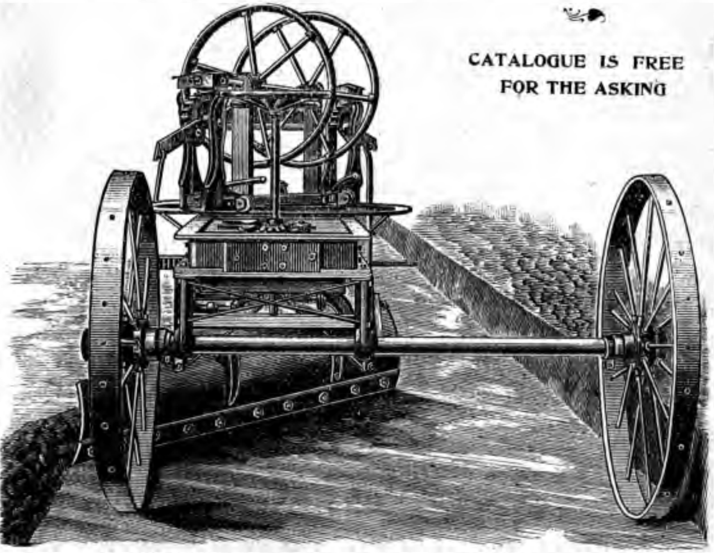

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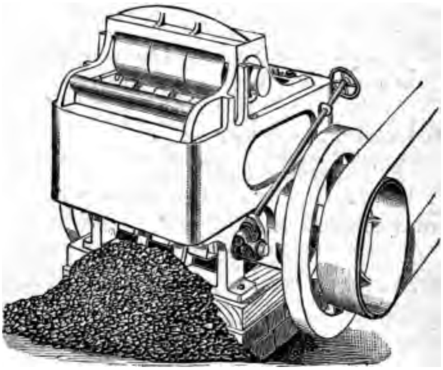

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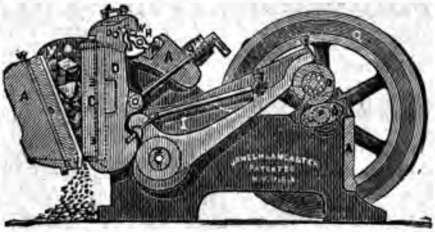

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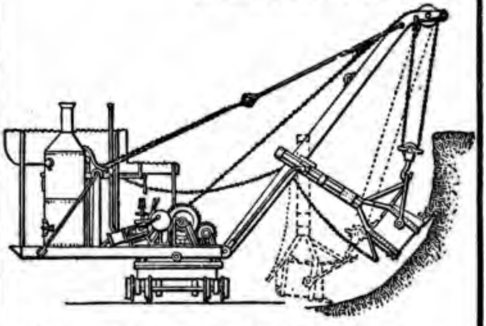

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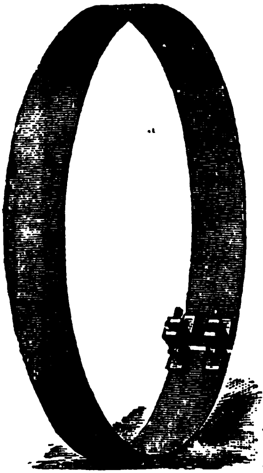

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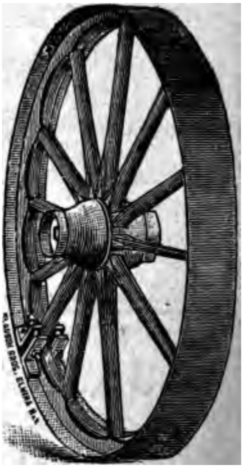

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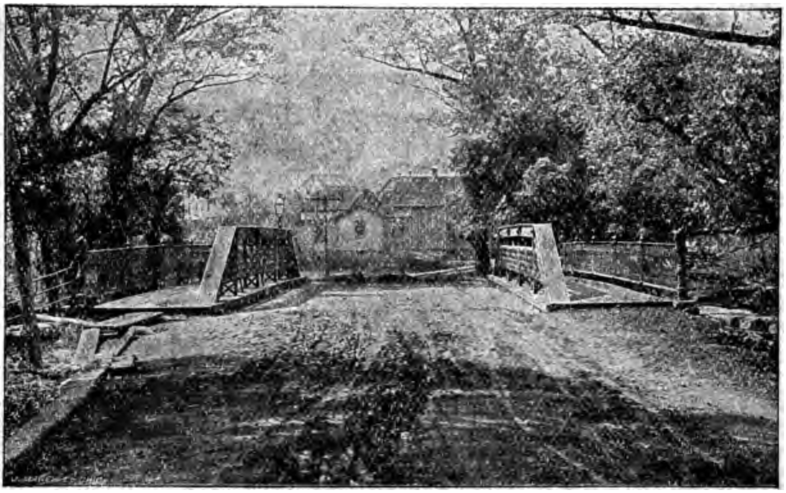

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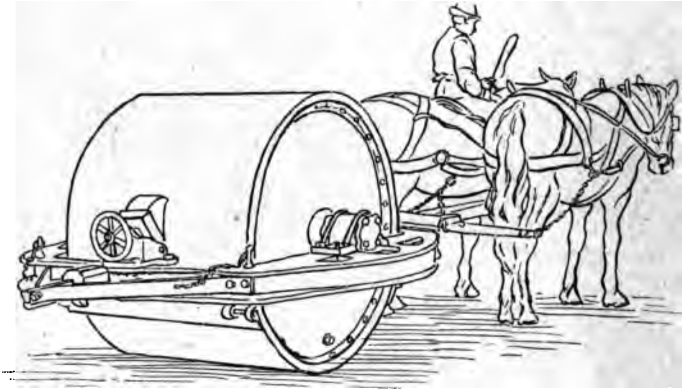

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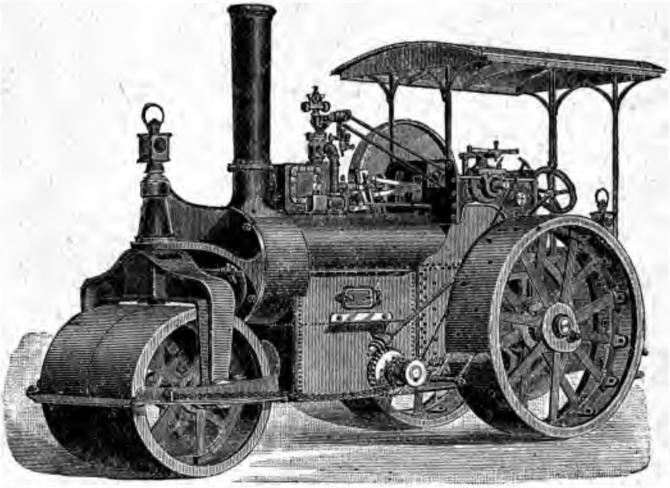

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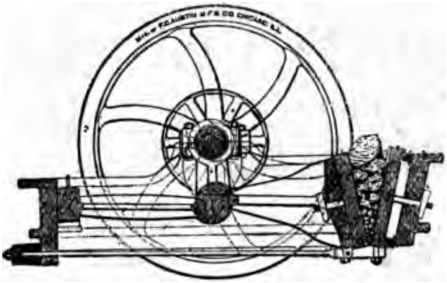

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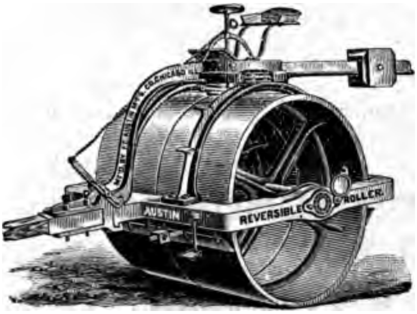

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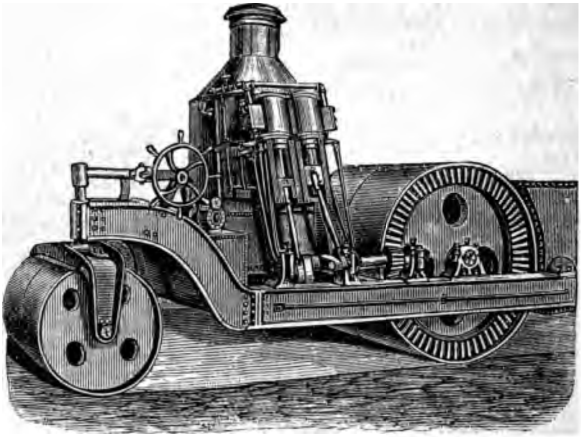

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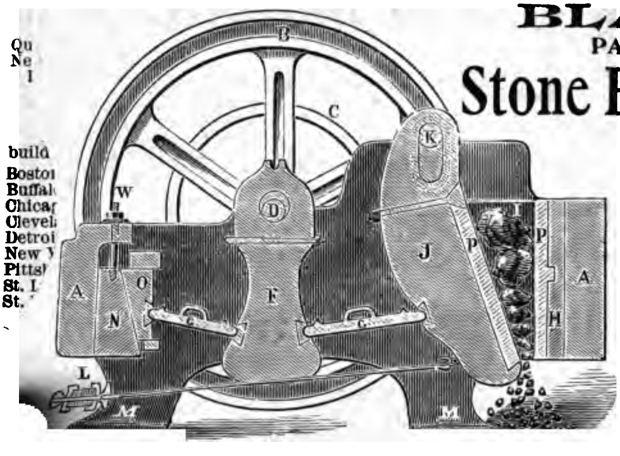

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